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STUDY OF AIR-TO-GROUND AND GROUND-TO-AIR TARGET HANDOFF

FORT HOOD FIELD UNIT

U. S. Army

Research Institute for the Behavioral and Social Sciences

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6 STUDY OF AIR-TO-GROUND AND
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FOREWORD

The Fort Hood Field Unit of the Army Research Institute for the Behavioral and Social Sciences (ARI), by assessing the human performance aspects of man/weapons systems evaluations in field situations, provides support to Headquarters, TCATA (TRADOC Combined Arms Test Activity; formerly called MASSTER--Modern Army Selected Systems Test Evaluation & Review). A war using modern weapons systems is likely to be both intense and short; U.S. man/weapons systems must be effective enough, immediately, to offset greater numbers of an enemy. Cost-effective procurement of improved and/or new combat systems requires testing that includes evaluation in operational settings similar to those in which the systems would be used, with troops representative of those who would be using the systems in combat. The doctrine, tactics, and training packages associated with the systems being evaluated must themselves also be tested and refined as necessary.

The present report presents the initial effort in a study of air-to-groung and ground-to-air target handoff procedures. This initial effort developed a concise definition of the problem by determining and describing the behaviors which underlie performance of the handoff task. The report also presents hypotheses to be tested for developing procedures to improve handoff procedures.

ARI research in this area is conducted as an in-house effort augmented by contracts with organizations with unique capabilities for human factors research. The present research was done jointly by personnel from the ARI Fort Hood Field Office and the Human Resources Research Organization (HumRRO), under contract DAHC 19-75-C-0025, and is responsive to the special requirements of TCATA and the objectives of RDTE Project 2Q763731A755, "Human Performance in Field Assessment," FY 1976 and 1977 Work Programs.

J. E. UHLANER,
Technical Director

STUDY OF AIR-TO-GROUND AND GROUND-TO-AIR TARGET HANDOFF

BRIEF

Requirement:

The research requirement specified that a study be made of air-to-ground and ground-to-air target handoff procedures.

The objectives were to:

- Develop improved target handoff procedures
- Recommend new target handoff procedures
- Produce a statement of Required Operational Capabilities (ROC) for new or revised equipment/instrumentation

Procedure:

This initial effort in studying target handoff centers around developing a concise definition of the problem. This process of definition was largely concerned with the determination and description of the behaviors which underlie performance of the handoff task. In addition, the conditions under which handoff is carried out was also determined and described. Knowledge of these behaviors and conditions form the basis for the development of improved handoff procedures. Herein described are the results of this effort as of the date of preparation of this report.

The research was conceived as a five-pronged effort:

- Review of Army documents, regulations, and training materials to determine current handoff procedures.
- Review of the technical literature to incorporate the findings of research related to the handoff problem.
- Interviews with individuals who have had extensive experience in target handoff.
- Survey of a group of individuals who have performed handoff, using a specially-developed questionnaire.
- Simulation of the essential elements of handoff that will allow collection of data concerning handoff as it is actually being performed.

Due to the current austerity program under which the Army is operating, it was not possible to acquire the resources to complete the simulation within the time-frame of the first year contract. The initial studies are in progress as of this writing, and will be the subject of a report to be issued early in the following year's contract. When data from these sources become available, they will yield a coherent picture of the task of target handoff, including existing procedures, conditions, tactics, and the underlying behaviors.

Principal Findings:

- There is no formal training in handoff.
- The elements of the handoff message are only broadly specified.
- Local unit Standing Operating Procedures (SOPs) are the basis for handoff procedures.
- Platoon leaders and company commanders are most likely to initiate a handoff; however, anyone with a need and access to radio can submit a request.
- The handoff experience of the officer sample contacted was extremely varied with few common attributes.
- Southeast Asian experience was general.
- Almost nothing of the procedures used in Southeast Asia handoff would be applicable to other combat situations.
- Considerable value may lie in studying the content of verbal communications between individuals in performing handoff.
- A simple simulator may be effective in providing experience in target handoff.
- The same simulator may serve as a test bed for examination of the usefulness of improved handoff procedures.

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CHAPTER 1

INTRODUCTION

It has been noted that it is relatively easy for ground observers to handoff (designate) ground targets to other ground elements. In this instance, both are viewing the target and surrounding terrain from a similar perspective. Similarly, a scout helicopter can relatively easily designate targets for Attack Helicopters (AH) -- again in this instance, the perspective from which both are viewing the target is similar.

It is, however, extremely difficult for ground observers to handoff targets to elements of air cavalry or tactical helicopter units. As an example, the ground observer may designate a target as being located among the tallest trees in a certain grid square, but the helicopter pilot will be unable to discern tree height from his viewing position. Conversely, a helicopter pilot may wish to have a ground unit fire on a group of enemy located on a trail bend. The bend will be a salient feature when viewed from above, but will not be at all obvious from the ground view. Thus, differences in perspective and the low likelihood that the ground and airborne observers will understand these differences contribute to difficulties in designating a target.

The usefulness of maps in target designation is low. The 1:250,000 scale map carried by aircraft is not adequate for use in target designation because of lack of detail. In addition, the accuracy of any given map is an unknown factor.

It was also considered that the recent experience in Southeast Asia (SEA) will not be repeated, and the techniques of target handoff that

were developed there will be inadequate for future combat. The Asian experience was characterized by unquestioned air superiority and the lack of local air defense by enemy combat units. The conflict was also basically an infantry or guerilla action with few defined positions and very little armor involvement.

Therefore, it was determined that a more effective means of designating targets for air-to-ground and ground-to-air was badly needed.

For the purposes of further defining the problem, a number of limiting assumptions were proposed. These assumptions were as follows:

1. Handoff will occur in an environment with topography and climate typical of central Europe.

2. Handoff will occur in a mid-intense conflict with conventional weapons only.

3. The conflict will be with a sophisticated enemy with an Electronic Warfare (EW) capability.

4. Local air superiority will be doubtful and the enemy will possess strong air defense capability.

5. Handoff will be from a platoon or company level observer to an AH or gunship. In addition, handoff may occur from a helicopter to a direct fire unit.

6. Handoff to USAF or Navy air support units will not be considered.

7. Direction to the target and designation of the target will be by voice channel -- which must be used sparingly. This worst case approach is dictated by the realistic assumption that combat conditions will degrade or render inoperable more sophisticated systems. This assumption also focuses the emphasis of the research on the most variable element in the handoff -- the human.

8. The aptitude or general educational level of ground observers will probably vary greatly. On the other hand, the helicopter pilots will probably form a more homogeneous group and will probably generally possess higher aptitudes and more education.

With these limiting assumptions in mind, an approach was developed to further define the problem of target handoff. As conceptualized, this approach was a five-pronged effort consisting of:

. Review of Army Regulations, training, training materials, doctrine, and tactics.

. Review of the relevant technical literature.

. Conduct of interviews with aircraft pilots and gunners, and with combat arms personnel experienced in ground-to-air and air-to-ground target handoff experience.

. Survey of a larger group of individuals with target handoff experience.

. Observation of individuals actually performing handoff.

The primary goal of this approach was to develop a full understanding of the target handoff task and to develop a model of the behaviors and processes involved. Once the task was understood, then hypotheses could be proposed for improving its performance.

The chapters that follow expand in detail on the approach that was taken in investigating target handoff. The final chapter will provide the conclusions that were drawn as well as point to directions for further research.

CHAPTER 2

REVIEW OF THE LITERATURE

Factors Involved in Air-to-Ground and Ground-to-Air Target Handoff

The literature which deals directly with the task of military target handoff is quite sparse. However, if the task is considered as consisting of a number of subtasks, each based on a hypothesized psychological process, then a larger body of literature can be examined.

The review will consider the task of target handoff under a series of broad topics:

- Related Communications Research
  - Verbalization of Visual Imagery
  - Cooperative Problem Solving
  - Communications Training
  - Lexicon Development
- Evaluation of Speech Communications
  - Intelligibility
  - Content Analysis
  - Stress and Intelligibility
  - Individual Differences in Pronunciation and Usage
- The Role of Land Navigation
  - Map Usage
  - Map Interpretation
  - Compass Use
- Target Location by the Ground Observer
  - Angle Estimation
  - Distance Estimation
- Low-Level Navigation
  - Geographic Orientation
  - Perspective Geometry
  - Instruction in Aerial Observation
  - Map Usage
  - NOE Training

. Target Location Training

  . Visual Search Strategies
  . Use of Error Keys
  . Ancillary Information
  . Visual Reconnaissance

. Federal Aviation Administration (FAA) Selection Research

  . Age and Performance
  . Personality Factors and Performance
  . Aptitude Factors and Performance

However, before each of these topics may be addressed, questions must be asked concerning the characteristics of the existing procedures, i.e., the adequacy of existing Army doctrine, the extent of Army training in target handoff procedures, and what is known of the relevant characteristics of the individuals who will be initiating or receiving the handoff.

Review of relevant Army documents reveals that procedures for handoff of targets to Army air elements are only grossly defined. Training Circular (TC) 17-17[1] states the approved target handoff message format consists of the following elements:

. Alert

. Acknowledgement

. Target Description

. Target Location

. Technique of Attack

. Method of Control

. Acknowledgement

. Execution

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[1]TC 17-17. *Gunnery Training for Attack Helicopters* (Draft), Department of the Army, US Army Armor School, August 1975.

Many of these elements are simple in nature and could be accomplished without special training or improved procedures. However, description of target location is not a simple task in a combat situation. The individual on the ground has the option of describing the target and its location by many methods; the final choice is determined by factors such as available resources and the prevalent tactical situation.

Among methods of target area description which may be used are:

- Grid Coordinates
- Range and Directions from a Known Point
- Range and Directions from Observer's Position
- Range and Directions from Smoke or Other Markers

The use of any of these methods requires the effective use of voice radio for success. Field Manual (FM) 100-26[2] points out that the ground commander and local Standing Operating Procedure (SOP) will determine the actual control of Army air elements in the target area. The reliance on local SOP is further pointed out in FM 44-10,[3] which states that adequate rules and procedures, delineation of responsibilities, and means for communication must be provided in SOP and plans. Further, these SOPs and plans should be exercised in the field prior to hostilities. Thus, the Army places its reliance for effective target handoff on procedures developed by the individual unit, and as far as could be determined, no formal training exists for target handoff procedures. A separate effort

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[2]FM 100-26. *The Air-to-Ground Operations System*, Department of the Army, March 1973.

[3]FM 44-10 (Test). *Army Air Space Control Doctrine*, Department of the Army, March 1973.

as part of the target handoff research will attempt to assess the extent of SOPs developed in conflict and assess their effectiveness.

With regard to the population of individuals who are likely to initiate a request for Army Attack Helicopter (AAH) support, FM 44-10[4] states that the commander of the supported unit or his designated representative will control the airborne fire support unit(s). Discussions with officers with Southeast Asia (SEA) combat experience reveal that the individuals most likely to institute a request for AAH fire support are the platoon leader or company commander. However, each officer also noted an instance in which a squad leader found himself in a situation requiring aerial fire support. In effect, there are no rigid rules which define who may or may not request aerial fire support and control the attack -- realistically, it may be anyone who has a need and access to operational, ordnance, or command communication nets.

A review of Army-sponsored research reveals no effort has been directly aimed at target handoff procedures, although several references were made to problems in this area. In a particularly relevant piece of work, Warnick and Jones[5] administered a questionnaire to Army aeroscout pilots and observers who had served in combat with air cavalry units. The survey was aimed at the examination of methods and techniques used in SEA with the objective of developing a basis for training development. In responding to the survey, pilots reported that communications with the Forward Air Controller (FAC) should be the subject of formal training.

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[4] *Ibid.*

[5] W. Warnick and D. Jones. *Aeroscout Pilot and Aeroscout Observer Responses to the Air Cavalry Tactical Information Survey*, HumRRO Research Product RP-D2-72-5, Human Resources Research Organization, Alexandria, Virginia, September 1972.

The respondents specifically noted that *brevity, exactness, and planning* were particularly important ingredients in effective airstrike control.

Subsequently, Warnick[6] asked a sample of Army helicopter pilots and observers to rate statements of skills or knowledges for a requirement in terms of their importance for combat job performance. The goal of Warnick's research was to identify skills and knowledges for an aeroscout training program. Warnick identified certain skills and knowledges, rated as important, that have application to the study of target handoff procedures. These were:

- Reporting information
- Briefing USAF forward air controllers
- Directing airstrikes
- Ability to relate terrain features to their representations by either map or photo

Researchers at the US Army Combat Developments Experimentation Command (USACDEC)[7] looked directly at the problem of unassisted ground-to-air target handoff. However, these studies suffered from a lack of combat realism; the observer was not required to direct the AAH to the target area and target location was given in either grid coordinates or a known search area. It was noted, however, that ground observers were never sure of how their perspective differed from that of the pilot. Additionally, enlisted observers were seen to be far less skillful in handoff when

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[6]W. Warnick. *Combat Job Requirements for the Air Cavalry Aeroscout Pilot and Aeroscout Observer*, HumRRO Technical Report 72-37, Human Resources Research Organization, Alexandria, Virginia, December 1972.

[7]*Attack Helicopter - Daylight Offense, Vol. V, Final Report, Phase I and II (Air-to-Ground Target Acquisition and Hand-off)*. Report No. FC 003, Department of the Army, US Army Combat Developments Experimentation Command, Fort Ord, California, May 1974.

compared to officers, their messages were longer, less precise, and tended to be "wordy." It was further noted that observers should give the pilot only general terrain features when designating the target; descriptions were often too "fine grained" for the AAH pilot to use effectively.

Related Communications Research

The problem of target handoff has received some attention in research sponsored by the United States Air Force (USAF). The impetus for this research was furnished by a study conducted in SEA by Simons.[8] Simons' survey revealed that a wide variety of techniques were used to designate target location. However, terrain features were heavily used in description of target location. Simons' findings appear to have great relevance to the problems of establishing effective target handoff techniques -- the major emphasis is on effective communications between forward observers located in low observation aircraft and high performance attack aircraft. Simons' findings are particularly relevant to a situation in which an individual must describe a target location to another who has a differing perspective of the terrain. These findings appear to apply directly to the target handoff as described in the Statement of Work for the current research effort.[9] Simons made the following recommendations for improving target location accuracy:

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[8] J. Simons. *Low-Altitude Reconnaissance Strike Techniques, Problems*, ASD-TR-67-17, Detachment 6, Aerosystems Division Liaison Office, South East Asia Air Force Systems Command, December 1967.

[9] Contract DAHC19-75-C-0025. *Human Factors Research in Military Organizations and Systems*, Army Research Institute for the Behavioral and Social Sciences (ARI), Arlington, Virginia, May 1975.

. When describing targets, start with large prominent landmarks and move down to smaller objects near the target.

. Never proceed with a target description until the recipient acknowledges a full understanding of the reference landmark.

. Use *relative* distance and bearing terms.

Each of these recommendations was properly interpreted as a hypothesis by the USAF and a considerable amount of research followed Simons' findings. The main thrust of the research concerned itself with the improvement of communications between the FAC and the Attack Aircraft (AC). This type of communication is found in tasks with an explicit goal in which two persons verbally exchange information in order to reach the goal.

Baldwin and Garvey[10] term the type of communication described by Simons[11] as *convergent* communication. Baldwin and Garvey define convergent communication as a communication in which two persons cooperatively exchange information in order to reach an explicitly defined goal. It was further specified that the two persons together have sufficient information to solve a given problem, but neither person is able to solve it alone. Therefore, a cooperation and convergence of information is necessary in order to reach a solution. Baldwin and Garvey further postulate a distinction between the functions of the two participants. One function is that of a *knower*, who is cognizant of the final form of the solution (e.g., the type and location of a target). The other function is that of a *doer*, who is aware of the problems which emerge in the course of the

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[10] T. Baldwin and C. Garvey. "Components of Accurate Problem-Solving Communications," *Journal of Educational Research*, Winter 1973, 10(1), 39-48.

[11] J. Simons, *op. cit.*

interaction and has the responsibility for executing the solution (e.g., firing at the target).

According to Baldwin and Garvey, there are five stages of problem solving under conditions of convergent communication:

1. Definition of the general problem.
2. Orientation of the doer to the knower's problem.
3. Identification of essential information.
4. Synthesis of the information and formulation of the solution.
5. Verification of the correctness of the solution.

Under this paradigm, success is largely determined by the ability of the individuals communicating to perform these cooperative components effectively.

As a direct followup of Simons' work, Morrissette[12] analyzed recordings of FAC/Tactical Aircraft (TAC) communications obtained under combat conditions in SEA. Morrissette began by ranking the missions on the basis of time from initial contact to strike to determine if differences in communications content existed between slow and fast missions. Morrissette then carried out a detailed content analysis of the ten fastest missions and the ten slowest missions. Morissette termed the fast missions *effective* and the slow missions *ineffective*. Under similar mission conditions, the individuals involved in the *effective* missions were seen to communicate more effectively than the individuals involved in the *ineffective* missions. The FAC in the effective missions used fewer words in directing a strike than an FAC involved in the ineffective missions. Of all comments

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[12] J. Morrissette. *A Content Analysis of Communications Between Forward Air Controllers and Tactical Aircraft Pilots*, AMRL-TR-70-95, Aerospace Medical Research Laboratory, Wright-Patterson AFB, Ohio, (in press).

received, 92.9 percent involved verbalizing the location of targets, airplanes, people, and guns. Morrissette felt that FACs should be well practiced in communicating their own location, describing target location, and recommending mode of ordnance delivery. Morrissette further recommended that emphasis should be placed on training FACs to identify terrain referents that are readily discernible by high-flying attack aircraft. Similarly, the FAC must be able to give direction information clearly, using relative units of measure. However, as Morrissette points out, it remains a question if the results obtained from his data would hold over different kinds of direct fire-support missions -- different terrain, day/night, etc. In a study similar to Morrissette's, Siskel and Flexman[13] studied air crew coordination under simulated conditions. They noted that with increased training, communication transmission rates decreased (i.e., the communicators spoke less frequently), while the number of expressions of complete thought also declined. Sigel and Federman[14] followed up on Siskel and Flexman's work with a series of studies designed to take a close look at communications between and among crews of antisubmarine attack helicopters. The crews performed simulated exercises and their communications were recorded. The resultant recordings were then subjected to a communications content analysis. Factor analysis was performed on the results of the communications content analysis of two studies. Three factors which were common to both studies were identified:

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[13]M. Siskel and R. Flexman. *Study of Effectiveness of a Flight Simulator for Training Complex Aircrew Skills*, Bell Aeronautics Company, 1962.

[14]A. Siegel and P. Federman. "Communications Training as an Ingredient in Effective Team Performance," *Ergonomics*, 1973, 16(4), 403-416.

1. Leadership Control

2. Probabilistic Structure

3. Evaluation Interchange

Siegel and Federman (pp 407-408) define these factors as follows:

> Leadership control connotes the provision of an atmosphere in which opinions of other crew members are allowed to emerge. This atmosphere prevails up to the point at which the team leader makes a decision. Prior to the decision making point, the opinions of others are solicited and welcomed, divergent opinions are allowed expression, data are accepted from all sources for consideration, and the formulation of hypotheses is encouraged. After all data are collected, the leader comes to a decision and insists that his crew carry out this decision. After the decision point, the atmosphere changes to that of command and control, so oriented that the decision is carried out ....
>
> The second factor denotes an active weighing of probabilities, a test of 'fair chance', a questioning of assumptions and of the appearance of truth. The factor implies that better teams make tests of plausibility and likelihood. These are characterized by 'what if' type statements and by information and opinion supporting the alternatives brought about by these statements. In brief, units maintaining this structure think logically and reason rather than perform routinely. Behaviour is marked by the desire to obtain more information and opinion before coming to a decision and the attitude reflects this permutative thinking. The behaviour underlying this factor can be further described as reflecting cohesive and interlocked communications which seek active exploration of the data and of alternative courses of action.

The third factor, *evaluation interchange*, was described as follows:

> This factor identifies communications in which there is an interchange of ideas, proposals, and data. The interchange entails an evaluative reciprocity between team members. Here are communications in which 'requests for' and 'provides' information come into play. The content supports and enhances a probabilistic structure and provides a basis for the thinking within the structure.

These three factors were then used as the basis for constructing an experimental course of instruction. The course was then evaluated using a two group, posttest only design. The subjects were drawn from a pool of

Navy helicopter crews at Ream Field, California. Sixteen crews composed each group. There were no differences in performance attributable to enhanced communication; the results were largely confounded by a difference in experience between the two groups. Inexplicably, no attempt was made prior to the experiment to determine if individuals assigned to the groups differed with respect to experience in the criterion task. Unfortunately, the group which did not receive the communications training was significantly more experienced than the experimental group. Additionally, Siegel and Federman could have obtained different, and perhaps, more useful factors if task-related performance variables had been included in the original analysis. The factors might then contain clues to communications content directly related to mission success.

Simons and Valverde[15] followed up on Simons'[16] earlier work and proposed a simple voice communications training program. They considered the task of verbalizing visual imagery as a critical FAC/TAC function. The criticality of this task was noted earlier by Whittenburg, et al.[17] Simons and Valverde describe a simple simulator/trainer which would provide visual/verbal experience to an FAC/TAC "team." This simulator presents identical scenes to both FAC and TAC players which differ in apparent altitude and occasionally in horizontal angle of regard. The

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[15] J. Simons and H. Valverde. *Voice Communications Training for Forward Air Controller/Strike Target Locators*, AFHRL(TR)-TRM-2, Advanced Systems Division, Wright-Patterson AFB, Ohio, January 1971.

[16] J. Simons, *op. cit.*

[17] J. Whittenburg, A. Schriber, J. Robinson, and P. Wordlie. *Research on Human Aerial Observation: Part I: Summary*, HumRRO Research Memorandum, Human Resources Research Organization, Alexandria, Virginia, July 1960.

images are on 35mm color slides which were shown to the subjects on back-projection screens. Preliminary assessment showed that the major portion of the time in a simulated strike mission was spent in verbalization of visual imagery. Experienced FACs could not discriminate between transcripts of communications obtained with the trainer and those obtained from actual combat missions. Additionally, Simons and Valverde were able to isolate skills which appeared to be important in effective target description. Briefly, these skills were seen to be:

. Accurate distance estimation.

. Ability to combine landmarks into a coherent description.

. A generalized ability to "decenter" perception and attend to the entire scene.

Other situational factors were identified which define the difficulty of the handoff task:

. Observer's bearing from AC location.

. Differences in altitude between observer and AC.

. Uniqueness of landmarks.

. Amount of scene structure.

Valverde, Kearns, and Woods[18] carried out a more formal evaluation of the FAC/TAC trainer. The evaluation used a pretest, posttest two-group design with 17 subjects in the untrained group and 18 in the trained group. The results of this evaluation showed that the group trained using the FAC/TAC trainer showed significantly greater skill gains than the untrained

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[18] H. Valverde, N. Kearns, and W. Woods. *Evaluation of a Device to Train Forward Air Controllers to Communicate Target Location*, AFHRL-TR-72-12, Air Force Human Resources Laboratory, Air Force Systems Command, Wright-Patterson AFB, Ohio, May 1972.

group. Transfer of training from the simulator to aircraft was then assessed using eight subjects from each of the two groups. The small number available for the transfer study and inadequate planning for rating flight behavior contributed to a poor outcome. Valverde, et al., felt that the tested groups did not provide a sufficiently wide base for a realistic evaluation. In addition, they also noted that the performance rating instrument was sensitive only to gross differences in performance levels. However, in defense of these workers, it should be pointed out that a transfer study was not included in the original research design. USAF officers who had observed the FAC/TAC trainer in use were, however, sufficiently impressed with its usefulness to cause two duplicates to be built. One was sent to SEA and one to Eglin AFB, Florida, for use in training FACs. Unfortunately, no hard data were obtained showing that the use of these devices resulted in increased airstrike efficiency.

Laveson and DeVries[19] also looked at USAF FAC/TAC communications and decided that a significant contribution would be a lexicon of terrain descriptors based on natural language preference. The same combat tapes analyzed earlier by Morrissette[20] served as the starting point for this research. Laveson and DeVries' analysis showed that the *ineffective* slow missions had the following characteristics:

1. More information statements.
2. Lack of terrain feature lexical agreement.

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[19] J. Laveson and P. DeVries. *Forward Air Controller-Tactical Air Command Pilot Communications and Orientation*, McDonald-Douglas Astronautics Corporation-East, St. Louis, Missouri, August 1973.

[20] J. Morrissette, *op. cit.*

3. Inaccurate absolute distance estimates.

4. Use of clock headings in preference to compass headings.

Following the analysis of the combat tapes, it was decided, on the basis of these findings, that a structured lexicon of terrain features would be effective in aiding target location. The effectiveness of labels in such a usage is generally supported by the literature.[21,22,23]

A group of experienced pilots was asked to view photos of 21 terrain features and give a name or label for each. This procedure generated 550 different labels. The photos were then grouped into six mutually exclusive categories by the judgment of the researchers. Subjects were given all pairs of photos within a category and asked to supply a single label for each one that would distinguish it from all others with which it was paired. However, a single label may not be effective. Eriksen[24] found that targets which could be labeled according to several unique characteristics could be detected more effectively. A content analysis of the unique labels was used to produce a lexicon of terrain descriptors. The lexicon was then evaluated as to its effectiveness in improving the ability to locate target and terrain features. The results of the

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[21] C. Eriksen. "Location of Objects in a Visual Display as a Function of the Number of Dimensions on Which the Subjects Differ," *Journal of Experimental Psychology*, 1952, 44, 56-60.

[22] C. Eriksen. "Object Location in a Complex Perceptual Field," *Journal of Experimental Psychology*, 1953, 49, 126-132.

[23] P. Katz and E. Zigler. "Effects of Labels on Perceptual Transfer: Stimulus and Developmental Factors," *Journal of Experimental Psychology*, 1969, 80(1), 73-77.

[24] C. Eriksen, *op. cit.*, 1953.

evaluation are unclear, as practice effects and individual differences in search strategies combined to swamp the effects of lexicon training. The possibility of combining a lexicon with training in search strategy was not explored. However, such a combination might prove effective in improving target location performance.

Evaluation of Speech Communications

Because of the important role of voice communications in target description and location information, it is appropriate to examine some of the methodology of communications analysis. Chambers[25] considered methods for evaluation of speech communications with particular reference to high-speed, low-level strike aircraft. Chambers pointed out that even though mission planners and tacticians can conceive of elaborate attack systems, the inherent unreliability of the communications process will likely seriously degrade the probability of mission success. Chambers then reviewed the state-of-the-art in communications evaluation and concluded that most of the techniques are related to intelligibility, and are laborious and time consuming to apply. Chambers further analyzed air-to-ground communications and recommended the Message Rate Efficiency Test (MRET) to analyze communications effectiveness. The MRET was developed by the British Telephone Administration and is described by Munson and Karlin.[26] The MRET was originally intended for use in measuring communications efficiency in two-way conversations in which the communicants seek to solve

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[25] A. Chambers. *A Review of Tests for the Evaluation of Speech Communication With Particular Reference to High Speed Low Level Strike Aircraft*, Technical Memorandum ED-543, Royal Aircraft Establishment, May 1973.

[26] W. Munson and J. Karlin. "Isopreference Method for Evaluating Speech-Transmission Circuits," *Journal of the Acoustical Society of America*, June 1962, 34(6), 762-774.

problems requiring an exchange of information. The communicants attempt to arrive at a solution by questions and answers in a minimum amount of time. The measure of message rate efficiency is the ratio of the average time to solve problems over the circuit to be evaluated to the time required when a high quality circuit is used. However, this method may not be of much use in studying the sort of problem posed by communications in target handoff. If enough time is spent communicating information about target location and the pilot has unlimited time to search, the probability that the target will eventually be located will become nearly unity. The effectiveness of a real mission, however, is highly dependent on the expenditure of a minimum amount of time. A criterion for communications efficiency in this instance might be if the target is identified within a time limit which is based on the maximum allowable for an effective mission.

A promising method of analyzing speech communications is described by Garvey and Baldwin[27] and Baldwin and Garvey.[28] This method was developed to analyze verbal interchange between two individuals mutually trying to solve a problem as discussed earlier.[29] Baldwin and Garvey term communications under such conditions as *convergent*. Their method, which relies on trained judges, produces categories of content which are consistent across a variety of tasks. In addition, high inter-rater reliabilities

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[27]C. Garvey and T. Baldwin. "Structures in Convergent Communication. I. Analysis of Verbal Interaction," *JSAS Catalog of Selected Documents in Psychology*, Winter 1972, 2, 17 (MS 77).

[28]T. Baldwin and C. Garvey. "Studies in Convergent Communication: II: A Measure of Communication Accuracy," *JSAS Catalog of Selected Documents in Psychology*, Winter 1972, 2, 18 (MS 78).

[29]T. Baldwin and C. Garvey, *op. cit.*, 1973.

are reported. This method of analysis is the only one encountered in the literature which is applicable to the target handoff problem. It appears to be very well suited to the sort of structured communication which must take place between air and ground. Analysis of target handoff messages using this technique may be quite revealing when *effective* and *ineffective* missions are compared. Baldwin and Garvey's work was based, in part, on a review and synthesis of the literature by Mehrabian and Reed.[30] Mehrabian and Reed conceptualized communication accuracy as a dependent variable which is influenced by variation in five sets of factors. These factors are:

- Attributes of the communicator.
- Attributes of the addressee.
- Characteristics of the communication channel.
- Characteristics of the message.
- Characteristics of the referent (object being described).

According to these investigators, the important attributes of both addressee and communicator are:

- Level of cognitive development.
- Coding rules employed.
- Attitude toward referent.
- Rate of information processing.

Relevant channel characteristics are:

- Number of channels.
- Probability of modification in transmission.
- Availability of feedback.

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[30] A. Mehrabian and H. Reed. "Some Determinants of Communication Accuracy," *Psychological Bulletin*, 1968, 70, 365-381.

Relevant message factors include:

. Degree of simultaneous redundancy of communication.

. Degree to which a communication is defined independently of the situation or context in which it is presented.

Relevant attributes of referents are:

. Ambiguity.

. Complexity.

Consideration of these factors and their effects on communication accuracy lead to the formulation of a number of hypotheses which will be valuable in guiding a study of communications in target handoff. In the case of any two individuals performing a handoff, there probably will be differences in the level of cognitive development of the participants. One index of cognitive development is age. However, differences in cognitive development also appear between adults. In adults, differences in the level of cognitive development appear as differences in personality, i.e., field-dependence/independence. According to research reviewed by Mehrabian and Reed, the accuracy of communication in a dyad appears fixed by the individual with the lowest level of cognitive development. Johnson and Gross[31] came to a similar conclusion, stating that communication accuracy may be a function of the extent to which the communicators' tendencies to name and describe objects are similar. The extent to which cognitive development could be modified is unknown; however, Brinkman[32] has had success in developing instruction for enhancing perceptual

[31] R. Johnson and H. Gross. "Some Factors in Effective Communication," *Language and Speech*, 1968, 11, 259-263.

[32] E. Brinkman. "Programmed Instruction as a Technique for Improving Spatial Visualization," *Journal of Applied Psychology*, 1966, 50, 179-184.

discrimination. It is also likely that coding rules, attitudes and the rate of information processing will differ between any two unselected individuals. Mehrabian and Reed quote limited data which show that communication accuracy was increased by the use of common coding rules by the two individuals communicating. Coding rules should also be well defined.

It can also be hypothesized that communication accuracy would be increased by the degree to which the decoder could act to control the rate of information processing. Accuracy of communication may also be enhanced by structuring the message format to ensure serial and simultaneous redundancy. Additionally, if a message can be freed from a limiting context it is more likely to be perceived accurately, i.e., a message must contain enough generalizable elements to be understood on its own. Finally, Mehrabian and Reed hypothesize that communication accuracy decreases as the information content (or complexity) of a referent increases.

Each of the attributes or characteristics suggests a hypothesis concerning communication in target handoff which can be readily tested in the laboratory.

A further consideration in communications effectiveness stems from the likelihood that speech communications efficiency will be affected by the stressed state of an individual in a combat situation. Asher, Doty, Hanley, and Steer[33] found that speaking and listening performances were degraded under experimental stress-producing situations. Unfortunately, their experimental model, which used competing tasks as stressors, does not approximate battlefield conditions. Nor was the existence of wide

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[33] J. Asher, L. Doty, T. Hanley, and M. Steer. *A Study of the Effects of Stress on Speaking and Listening Abilities*, NAVTRADEVCEN 104-2-50, Technical Department, Naval Training Device Center, Orlando, Florida, February 1957.

individual differences in susceptibility to stress addressed. Hecker, et al.,[34] noted that fundamental voice frequencies shifted under conditions of stress. Hollien, Rothman, and Feldstein[35] noted that low fundamental frequencies were associated with better intelligibility; however, the data gathered by Hecker, et al., showed that the direction of fundamental shift was highly variable from individual to individual. Hollien, et al., also noted that superior speech intelligibility was associated with a low speech rate and high intensity. These findings may have importance in developing training techniques or perhaps as a basis for selection of individuals who could produce more intelligible target location descriptions. However, it will be necessary to perform a study to determine a speech rate which is intelligible and yet consistent with the combat requirement for rapid message transmission.

At this point it seems valuable to insert work which related language differences to communications intelligibility. The personnel composition of the US Army is a mirror of the wide diversity of ethnic backgrounds and regional influences which characterize the general US population. Therefore, it is likely that broad differences may exist in word usage, pronunciation and general familiarity with English.

Differences in usage and accent may have an impact on the target handoff problem. Moser looked at the impact on listener understanding of

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[34]M. Hecker, K. Stevens, G. von Bismarck, and E. Williams. *The Effects of Task-Induced Stress on Speech,* Bolt, Beranek, and Newman, Cambridge, Massachusetts, 1967.

[35]H. Hollien, H. Rothman, and S. Feinstein. *Underwater Speech Communication,* CSL/ONR No. 48, Communications Science Laboratory, July 1972.

English words pronounced by individuals who native language was not English.[36] As the Army accepts many individuals to whom English is a second language, Moser's findings may be important. Moser analyzed recordings of words and phrases and developed a lexicon of varying pronunciations commonly encountered. Such a lexicon of commonly used words and their pronunciations may be useful in communications training for target handoff. In related work, Moser, Fotheringham, and Gonzales[37] examined air traffic messages to determine if pilots and controllers adjust their rate of speaking to match perceived listener needs. In this case, the cues used by the speaker to judge listener needs stemmed from accent and pronunciation, indicating the other party was of foreign origin. In general, Moser, et al., found that a slower rate was used when the speaker judged he was talking to a person whose first language was not English. Rate of speaking and the interactions between rate and listener characteristics will probably affect intelligibility of the handoff message and are therefore worthy of study. In a somewhat related effort, Kidd[38] investigated air traffic controller team performance under conditions of communication channel interference and interruption. An important finding was the importance of feedback and the role of sender/receiver cooperation in overpowering communication barriers, i.e., the recipient should

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[36] H. Moser. *The Pronunciation of English Air Traffic Control Words by Controllers From 12 ICAD Nations,* Ohio State Research Foundation, Columbus, July 1964.

[37] H. Moser, W. Fotheringham, and C. Gonzales. *Variance in the Rate of Speaking by Pilots and Controllers in Communications to U.S. and Foreign Listeners,* Ohio State Research Foundation, Columbus, 1967.

[38] J. Kidd. *Work Team Effectiveness as a Function of Mechanical Degradation of the Communications System,* ESD TN 61, 1957.

acknowledge receipt of information and communicate his understanding of it. In turn, the individual sending the information should be willing to provide clarification or additional information as required.

From this limited body of research, it can be determined that the process associated with verbalization of visual imagery plays an important role in successful handoff. However, it is also very important for the individual on the ground to be sure of his own location before he can effectively direct the aircraft to a location near his own position. Land navigation skills are then important in determining an effective handoff.

The Role of Land Navigation

Fortunately, there has been extensive programmatic research directed at the problem of developing accurate land navigation skills. Findlay, Roach, and Cogan[39] determined that four factors seemed to account for much of the variance in land navigation performance. These factors were:

1. General reasoning.
2. An unidentified mixed factor.
3. Spatial relations.
4. Compass skill.

In Findlay, et al's., research Army enlistees were given a short review of land navigation principles, performance tests of location, and compass use skills. The testing also included a criterion test of land navigation skills, a location test, and a battery of standard aptitude tests. The criterion test consisted of six routes over which the subject

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[39] D. Findlay, D. Roach, and E. Cogan. *Identification of the Important Skills in Daylight Land Navigation*, HumRRO Technical Report 40, Human Resources Research Organization, Alexandria, Virginia, July 1957.

was to navigate to a predetermined area. The performance of their subjects on the criterion test paint a rather gloomy picture of what can be expected when a ground observer relies on an estimate of his own position to vector in an airstrike. The men in Findlay, et al's., study successfully completed an average of 2.3 of six routes, and 17 percent of them failed all six routes. The test scores were then intercorrelated and a factor analysis performed. The highest Multiple Correlation with the criterion test was achieved by a composite formed of tests of contour visualization, the location test, and a measure of orientation by inspections.

In a later look at land navigation, Follettie[40] concluded that the two basic techniques of land navigation were dead reckoning and map-terrain association. Dead reckoning is a purely mechanical process; however, it is subject to errors in direction finding and distance estimation. In map-terrain association, the individual compares a representation of terrain with the terrain being navigated. If the individual has been initially well oriented and has a general sense of ground and map direction, it is possible to move in a general direction over representative terrain, making adjustments enroute. The major difficulty in navigating effectively by dead reckoning is the high reliance on map reading skills, which are often deficient. Follettie proposed a technique which combined features of dead reckoning and map-terrain association. Using this technique, the individual would initially follow a dead reckoned route and then modify

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[40] J. Follettie. *A Performance Requirement for Basic Land Navigation,* HumRRO Research Report 4, Human Resources Research Organization, Alexandria, Virginia, March 1960.

his route on the basis of feedback from prominent terrain features. As a followup of his notion, Follettie[41] developed and evaluated a course of instruction based on dead reckoning supplemented by map-terrain association. The course involved instruction in compass use, distance measurement, and map-terrain association. The evaluation showed that the training was effective in improving land navigation accuracy. Trainees experienced greatest difficulty when the terrain was unobstructed, with few dominant features, few cultural features, and sparse to moderate vegetation. Powers[42] followed Follettie's basic lead and developed an Advanced Land Navigation (ALN) course for Army infantry. Initially, Powers found that only five percent of his experimental subjects were able to meet navigation performance requirements for a difficult route. Powers' subjects had all received the Army's basic combat training which includes instruction in land navigation. The ALN course consisted of training in the following land navigation techniques:

1. Compass use.

2. Pace measurement for distance determination.

3. Detouring -- how to maintain correct heading when forced to detour from a planned route.

4. Map reading skills.

Fifty percent of the course time was assigned to practical problems. Map-terrain association was not emphasized; however, during day practical

[41] J. Follettie. *Development and Evaluation of a Program of Instruction in Basic Land Navigation*, HumRRO Technical Report 70, Human Resources Research Organization, Alexandria, Virginia, May 1961.

[42] T. Powers. *Advanced Land Navigation: Development and Evaluation of a Prototype Program of Instruction*, HumRRO Technical Report 89, Human Resources Research Organization, Alexandria, Virginia, April 1964.

exercises the trainee was given a map to allow him to practice map-terrain association. Evaluation of the ALN course showed that 50 percent of the trainees were able to correctly navigate the most difficult route.

McGuigan and Grubb[43] proposed that effective map use requires the ability to relate the nature of the meandering contour lines to the shape of a terrain feature. Three techniques were used to strengthen the association between a terrain feature and its contour map representation. These techniques were: (1) terrain board, (2) 3-D slides of terrain, and (3) 2-D slides of terrain. In addition, two types of map were used, a normal flat map and one with a raised surface which imitated actual terrain relief. Their criteria were a measure of contour interpretation and a measure of contour visualization. The results of this investigation showed that the most effective method for presenting contour is the raised-surface map. Similarly, the most effective way of presenting terrain is the 2-D slide. McGuigan and Grubb explain this rather startling finding on the basis that their trainees were used to seeing flat pictures of land, which have none of the distorting stimuli of 3-D slides and usually entail less loss of size than does the terrain board. Learning in the paired-associate mode using 2-D slides and raised-surface map should result in an enhanced capability to relate terrain to contour. The question of transfer of this skill to a realistic land navigation task was, however, not addressed.

In an area of inquiry related to map reading, Edmonds and Wright looked at the role of topographic map scale in determining errors in

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[43]F. McGuigan and J. Grubb. *Several Methods of Teaching Contour Interpretation,* HumRRO Technical Report 35, Human Resources Research Organization, Alexandria, Virginia, January 1957.

position location.[44] Two map scales were investigated: 1:25,000 and 1:250,000. After receiving a brief map-reading course, the subjects were required to plot their location on a map at each of 12 terrain locations. The dependent variable was location error. Mean error using the 1:25,000 scale map was 143 meters, while for the 1:250,000 map, the error was 1400 meters. Very large errors were thought to be due to the subjects becoming disoriented. Other large errors were thought to be due to the subjects paying insufficient attention to contour information. The central trade-off in Edmonds and Wright's view is between the higher accuracy obtainable with larger map scales and the greater bulk of these maps. The authors suggest that different methods of relief-coding be investigated, particularly those which would allow relief to be perceived directly without interpretation. However, they offer no suggestion as to how this might be accomplished.

Thus, there seems to be an extensive body of literature concerned with the problem of accurate land navigation. Techniques have been investigated and training programs developed which are capable of enhancing performance in land navigation and map reading. The reasons why they have not been implemented are not readily apparent. There still remain some questions to be answered, however, about the persistence of these skills and their transfer to realistic combat situations. Additionally, it seems that some innovative work is required to develop a more useful means of representing terrain than the traditional topographic map.

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[44] E. Edmonds and R. Wright. *The Effects of Map Scale on Position Location*, HumRRO Technical Report 65-9, Human Resources Research Organization, Alexandria, Virginia, September 1965.

Target Location by the Ground Observer

Once the observer is in position and has a relatively good notion of his own location, he must be able to estimate the range and azimuth of the target from his position or from another known position. Estimation of azimuth is relatively easy if a lensatic compass is used. However, if for some reason a compass is not available, angle estimation is possible, although if attempted without special training, is not particularly accurate. Logan[45] found that his subjects tended to underestimate angles between 15 degrees and 75 degrees with error increasing as the angle increased. The 15 degree angle was estimated most accurately with the 90 degree angle next most accurately. Waller and Wright[46] conducted training in angle estimation and achieved a similar finding to Logan's. While training resulted in an increase in the accuracy of estimating angles, the greatest accuracy was achieved with smaller angles with accuracy decreasing as the angle increased. Individuals performed best using a map and performance on the map items did not show significant deterioration after a week had passed. Thus, if an individual already has knowledge of his own location, he can, with appropriate training, estimate the azimuth of an object from his position.

Distance estimation is also important, and while there soon may be accurate ranging devices in the Army inventory of equipment, the possession of a working range estimation device cannot always be assumed. In a

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[45] O. Logan. "Estimation and Reproduction of Angles from a Given Line of Reference," *Perceptual and Motor Skills*, 1964, <u>18</u>, 231-234.

[46] T. Waller and R. Wright. *The Effects of Training on Accuracy of Angle Estimation*, HumRRO Technical Report 65-8, Human Resources Research Organization, Alexandria, Virginia, August 1965.

followup of the lead taken by Simons,[47] Aume[48,49] looked at the effectiveness of unconventional measurement units in a target location task. Using a reduced scale simulation with a relatively long detection range, Aume found the following:

. Estimation of lateral distance using conventional measurement units is extremely inaccurate.

. There is little relationship between the ability to estimate short distances and the ability to estimate long distances -- longer distances are associated with greater error.

. Background features influence distance judgments.

. The use of a reference distance dramatically reduces inter-subject variability.

Aume's findings in regard to accuracy in distance estimation are consistent with those reported by Galanter[50] and Laveson and DeVries.[51]

Gibson and Bergman[52] looked at the effects of training on absolute and relative judgment of distance over ground. Their results showed that experience in estimating distance with feedback as to accuracy was effective in improving the ability to judge distance. Gibson, Purdy, and

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[47] J. Simons, *op. cit.*

[48] N. Aume. *Estimation of Target Locations with Conventional Measurement Units*, AMRL-TR-69-21, Aerospace Medical Research Lab, Wright-Patterson AFB, Ohio, September 1969.

[49] N. Aume. *Human Estimation of Proportional Distances and Distance Ratios With the Aid of a Reference Length*, AMRL-TR-70-78, Aerospace Medical Research Lab, Aerospace Medical Division, Wright-Patterson AFB, Ohio, June 1971.

[50] E. Galanter. *Range and Time Estimates of Dynamic Visual Targets*, PLR-27, Psychophysics Laboratory, Columbia University, New York, August 1972.

[51] J. Laveson and P. DeVries, *op. cit.*

[52] E. Gibson and R. Bergman. "The Effect of Training on Absolute Estimation of Distance Over the Ground," *Journal of Experimental Psychology*, 1965, 48(6), 473-483.

Bergman[53] studied a training technique in which the subject was asked to progressively fractionate a known distance. The subject was given feedback as to direction and approximate extent of errors. This training was followed by a criterion test of the ability to perform absolute judgments of distance. A different stretch of ground was used for this test. Gibson, Bergman, and Purdy concluded that training under these conditions produced an ability to judge distance similar to that obtained when training and subsequent performance were carried out over the same ground (as in Gibson and Bergman[54]). Gibson, Bergman, and Purdy performed a second experiment in their study in which they looked at the performance of subjects to estimate distance by judging if a target was at a distance "farther, equal or nearer" to a target located at a standard distance. The standard distance and the experimental distance were located at a 120 degree angle to one another. The subjects were trained as in Gibson and Bergman's study. Their results showed that differential sensitivity in distance judgment was not affected by the training. A common conclusion from the studies of Gibson and Bergman and Gibson, Bergman, and Purdy was that "a psychophysical scale exists based on the texture of optical gradient which is correlated with judgments of greater or lesser distances." It must be pointed out that the textures over which distance judgments were performed were similar in all of these experiments. The question remains

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[53] E. Gibson, R. Bergman, and J. Purdy. "The Effect of Prior Training With a Scale of Distance on Absolute and Relative Judgments of Distance Over Ground," *Journal of Experimental Psychology*, 1955, 50(2), 97-105.

[54] E. Gibson and R. Bergman, *op. cit.*, 1965.

unanswered of whether or not training would transfer from terrain characterized to one variety of optical texture (i.e., grass) to another (i.e., broken rock).

McCluskey[55] conducted research with moving aerial targets and reported that relatively accurate estimation of range could be made using a relatively simple stadimetric ranging device. Constant errors associated with the direction of movement of the targets were present, but the technique is still useful, particularly with stationary targets.

Thus, it appears that if a sophisticated equipment is unavailable, training or job aids will provide a capability for describing target direction and range with sufficient accuracy to enable the pilot to find the target.

Low Level Aerial Navigation

In addition to the need for the ground observer to know his own location, it is also important that the AAH pilot be able to estimate his own location with sufficient accuracy to enable him to proceed to the target area in a timely fashion. Geographic orientation is probably the primary process by which the pilot estimates his own position. Webster defines geographic orientation as *"a determination or sense of the position of one's aircraft in relation to its geographic environment, in particular, in relation to the earth's surface and its natural and man-made features, and in relation to defined geographic coordinate systems."* Wright quotes

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[55] M. McCluskey. *Studies on Reduced Scale Ranging Training With a Simple Range Finder*, HumRRO Technical Report 71-24, Human Resources Research Organization, Alexandria, Virginia, December 1971.

an Army source which states that lack of geographic orientation appears to be a causal factor in approximately 80 percent of Army aviation accidents.[56] Wright distinguishes essentially two instances in which geographic orientation is used. These two instances can be differentiated in terms of the specific task load presented to the aviator. Wright refers to these instances as *close-in geographic orientation* and *local area geographic orientation*. In close-in orientation, the pilot must attend to terrain and features within about a 100-meter radius around the hovering AAH. An example of a task involving close-in orientation would be a helicopter pilot searching a specific landing area. The relationship between altitude and terrain orientation must also be taken into account. Primary geographic orientation is maintained currently only by the pilot's direct vision. In local area orientation, the pilot must be able to remain oriented in an area approximately 100 meters by 8000 meters. As an example in performing a fire-support mission, local area orientation would be of primary importance. The pilot would approach a target area, relying on his local area orientation and then switch to a reliance on close-in orientation to locate the target. The purpose of Wright's formulation was to shift the emphasis of navigational system development away from hardware to a careful consideration of the information requirements of the pilot. These requirements appear to be different at the various stages of a mission.

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[56] R. Wright. *Orientation Systems: First Things First,* HumRRO Professional Paper 3-70, Human Resources Research Organization, Alexandria, Virginia, February 1970.

Hagen, Larue, and Ozkaptan[57] performed a study that is of particular relevance to the target handoff question. Hagen, et al., attempted to determine if the ability to locate a target area could be improved through special training. They were concerned with providing effective training to operators of airborne TV-guided weapon systems. They hypothesized that special training in perspective geometry when added to conventional training in target location would aid in achieving accurate orientation to a target area. These authors defined perspective geometry as the study of spatial relations on the ground and how they change when the angle of view is varied. Hagen, et al., designed the conventional training to closely approximate techniques then known to be in use. Observers were briefed on the target area using a 1:20,000 photomosaic. During this briefing, the observers were to learn all potential checkpoints (i.e., terrain features and manmade features). When the subject was capable of producing a rough facsimile with checkpoints in correct relationship with the target area, he was permitted to view the same terrain on a TV monitor. The view on the monitor simulated that from a TV sensor mounted on an aircraft flying toward the target area. The subject was required to identify the target area. If the subject was not successful, feedback was provided and the subject was allowed to view the simulation again. There was no limit on the number of trials.

The special training was completely static. The bulk of the training materials consisted of a packet of maps showing 21 different checkpoint-to-

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[57] W. Hagen, M. Larue, and H. Ozkaptan. *Effects of Perceptive Geometry Training on Target Area Location,* Martin-Marietta Corporation, Orlando, Florida, October 1966.

target relationships. Secondly, simulated TV displays with decreasing numbers of range and cross-range markers were prepared. As the subject learned the display geometry, more cues were removed. The packet of materials also contained a series of overlays showing only the checkpoints and 21 different checkpoint-to-target relationships simulating their appearance on the TV monitor face. The subject was asked to locate the target area in relation to a checkpoint. Answer sheets provided immediate feedback to the subject on the source of his error. Six subjects were randomly assigned to each of two groups. The subjects in the control group received the conventional training only. Experimental group subjects received both the special and conventional training. The training was then evaluated by requiring the subjects to locate targets in a simulated situation. The results showed that the experimental group subjects were able to locate targets significantly faster than control subjects, although the groups did not differ in location accuracy.

An attempt was also made to assess the subjects' notions of the principles they used in performing the target location task. Checkpoints and how they were chosen was mentioned frequently. With regard to the target handoff situation, several principles of checkpoint usefulness were proposed which seem to be important in efficient target location:

1. To be a useful checkpoint, a feature must be unique to the area.

2. The feature must be visible under varying conditions.

3. The feature must be located at some optimum distance from the target.

These findings predate the USAF interest in target location by reference to terrain. However, several questions remain unanswered by

Hagen, et al's., research, i.e., what is the optimum distance between a feature and a target, and what are the attributes of uniqueness? Thomas[58] devised a combat simulation aimed at discovering the important skills in low-altitude aerial observation. Four necessary skill areas were identified:

1. Detecting targets quickly by mechanical visual search.
2. Identifying targets quickly.
3. Performing geographical orientation.
4. Determining the location of targets.

Thomas then used this information as the basis for developing a course of instruction. The performance of observers trained under this experimental regime was compared to that of conventionally-trained individuals. The experimental training proved to be more effective as well as more efficient than conventional training. In related work, Thomas and Caro[59] conducted five studies dealing with low-altitude aerial observation. Two of the studies are of particular relevance to air-to-ground handoff. The first of these explored the practicality of developing training which would enhance the ability of an observer to maintain his geographical orientation while in flight. According to Thomas and Caro, location of a target may be conceived of as two separate events. First, the observer must determine his location by reference to a map. Second, the observer locates the map position of the seen object. The observer, therefore, must

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[58] F. Thomas. *Low Altitude Aerial Observation: An Experimental Course of Instruction*, HumRRO Technical Report 80, Human Resources Research Organization, Alexandria, Virginia, October 1962.

[59] F. Thomas and P. Caro. *Training Research on Low Altitude Visual Aerial Observation: A Description of Five Field Experiments*, Research Memorandum 8, US Army Aviation Human Research Unit, Fort Rucker, Alabama, 1962.

be geographically oriented in order to determine the map location of the object. Thomas and Caro further noted that to maintain geographic orientation, an observer must be able to identify preselected terrain features along the flight path. Accordingly, an experimental course of training devised to improve the ability of students to remain geographically oriented. A subsequent experiment demonstrated that the ability to maintain orientation was indeed related to ability to accurately locate targets.

The second study of interest by Thomas and Caro investigated further the relationship between the ability of an individual to orient himself and the ability to locate a target. Orientation training similar to that described above for the first study was administered to several groups. These groups were differentiated on the basis of a varying delay between training and field testing. This varied delay was introduced to allow study of the effects of a delay between training and performance. It was hypothesized that the delay would have little effect if the training were easily generalizable to the field situation. The orientation training was effective in producing reduced target location errors, while the delays were seen to have no effect. However, some students were consistently better than others in target location, which suggests that selection might be effective in identifying individuals with these skills.

Dawkins[60] looked at the effectiveness of programmed instruction in enhancing aerial observation skills. This work was based on the results of Thomas, and Thomas and Caro reported earlier. The course content dealt with four basic skills which seemed to underlie performance in low-altitude

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[60] P. Dawkins. *Programmed Instruction and Low Altitude Aerial Observation*, HumRRO Research Report 14, Human Resources Research Organization, Alexandria, Virginia, December 1964.

aerial observation: (1) visual search, (2) target recognition, (3) topographic orientation, and (4) target location. The programmed course was compared to its conventional counterpart (verbal and visual) developed by Thomas. The results revealed that the programmed course took less time and was more effective in meeting course criterion performance requirements.

The problem of geographic orientation received further attention from McGrath, Earl, and Osterhoff.[61] These investigators proposed that the task of maintaining geographic orientation by map reference be time-shared between a pilot and a second individual serving as a plotter. In their conception, the plotter would have the flight plan and follow the progress of the flight on a map while in voice communications with the pilot. The plotter's job would be to ascertain the aircraft's current position with reference to the map and inform the pilot of any required corrections. In evaluating this concept, under conditions of simulated flight, McGrath, et al., compared the navigation performance of pilots doing their own navigation and when aided by plotters. They found that the distribution of pilot and plotter navigation errors almost completely overlapped. Plotters, however, performed better in maintaining orientation than the pilots over difficult routes. Plotters also performed better under conditions where a large navigational error was encountered, i.e., they recognized the extent of the deviation from the planned course and effectively corrected it. The additional work load placed on the pilot under realistic flight conditions may, however, serve to enhance the obtained differences between the methods. It is not known if this technique has

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[61] J. McGrath, W. Earl, and W. Osterhoff. *Geographic Orientation in Aircraft Pilots: A Simulator Test of a Team Method of Reporting Target Locations*, Technical Report 751-12, Human Factors Research, Inc., Goleta, California, October 1967.

been used with AAHs; however, if it is effective then the relative efficiency of navigation to the target area should be increased. Increased navigational accuracy should result in more timely arrival of the strike and, hence, a greater chance of survival and successful engagement.

Gray, Waller, and Wright[62] looked at techniques for low-level aerial navigation. They found that there are two basic requirements for successful low-level navigation. These requirements are accurate course heading and the ability to use maps.

Gray, et al., considered that the task load on the pilot could be lessened by using tactical maps in lieu of the current plotting techniques. Accordingly, an experimental training program in heading estimation was developed. Specifically, the training was directed at enhancing a subject's ability to estimate compass heading, or direction from one point to another using Army maps. Two map scales were used: 1:250,000 and 1:100,000. As might be expected, smaller errors in angle estimation were found when the 1:100,000 scale map was used. Differences in accuracy were also found related to distance between reference points and location within compass octant. In general, longer distances between reference points resulted in smaller errors, while accuracy was better for the cardinal octants, i.e., N, S, E, and W. Training and experience were also seen to produce reductions in error. However, even after training, a number of subjects were still making errors in excess of five degrees. The existence of

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[62] T. Gray, T. Waller, and R. Wright. *Techniques for Low Altitude Navigation: Direction Estimation From Tactical Maps,* HumRRO Technical Report 67-4, Human Resources Research Organization, Alexandria, Virginia, April 1967.

stable individual differences in accuracy of angle estimation suggests the possibility that selection might provide individuals who are better navigators. This study implies that large navigational errors can be expected when navigating by dead reckoning at low altitudes and could be a significant factor influencing the effectiveness of a fire mission.

In an expansion of the study reported by Gray, et al,[63] Wright and Pauley[64] estimate that with a helicopter flying Nap-of-the-Earth (NOE), the pilot's information processing accuracy may be no better than 10 percent. They also quote test data and operational reports which indicate a reduced navigational effectiveness in low-level flight.

Wright and Pauley noted the following operational and environmental factors as important in any consideration of low-level aerial navigation:

1. Rapid reaction missions are likely to be encountered for which little or no planning time is available.

2. Low-level flight is characterized by low obstacle clearance which will limit viewing area and time.

3. In low-level flight, planar features which may be used in navigation are in view for only a limited amount of time.

4. Correlation of map and terrain in low-level flight requires time-based reconstruction of briefly viewed features.

5. Large mission areas are particularly difficult to deal with particularly when coupled with frequent inability to predict the location of the next mission.

6. Low-level operation over unfamiliar terrain is likely to be hazardous.

7. In low-level flight, care is needed in approach to target as it may be missed.

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[63] *Ibid.*

[64] R. Wright and W. Pauley. *Survey of Factors Influencing Army Low Level Navigation,* HumRRO Technical Report 71-10, Human Resources Research Organization, Alexandria, Virginia, June 1971.

8. Effective engagement is often based on the precision of estimated time of aircraft arrival at target area. This is often particularly difficult in low-level flight.

9. Greater speed in approach will give less time to attend to navigational functions.

10. Further degradation in low-level flight navigation can be expected in operations in darkness and limited visibility.

11. Maps with a usable level of detail are often too bulky to be carried in the aircraft.

12. Maps with optimum scale for low-level flight are not available.

13. Navigational effectiveness will be further hampered by a cockpit design whose physical characteristics preclude effective human performance required for NOE.

14. There are currently no useful automatic navigational systems for low-level flight.

15. Addition of Instrument Flight Rules (IFR) equipment will likely interact with poor cockpit design to further degrade performance.

This list serves to illustrate some of the problems faced by the pilot who must navigate NOE.

Wright and Pauley point out that planning navigation for an NOE flight should include:

1. Familiarity with terrain.

2. Familiarity with the known and likely locations of enemy forces with respect to terrain characteristics.

3. Ability to map out a route, making most use of good checkpoints.

4. Determination and marking off on the map the heading for each flight segment.

5. Marking off of the route line in time units.

6. Notation on the map of important information, such as FEBA, etc.

Wright and Pauley also noted that once in flight, the primary NOE navigational tasks are:

1. Perceptually correlating the view of external terrain with its representation on the map.

2. Minimizing lateral offset of error from desired ground route.

3. Minimizing longitudinal offset or error.

Wright and Pauley feel that significant improvement in NOE navigation accuracy is dependent on improvements in navigational equipment. Once improved equipment is available, procedures can be specified and training needs minimized. Unfortunately, however, such equipment, if any, will probably be retrofited to existing aircraft and its effectiveness will suffer.

In recognition of the lack of accuracy in NOE navigation, Holman[65] described map interpretation and terrain analysis training developed by the Army Research Institute for the Behavioral and Social Sciences (ARI). This training was specifically designed to improve NOE navigation skills. The course materials emphasize understanding of cartographic principles, map interpretation, and terrain analysis. The materials consist of a series of exercises which feature wide-angle motion pictures of NOE flight. The flight films served to reinforce the importance of the particular skill under instruction. Detailed feedback on trainee performance was given by the instructor in a post-exercise briefing. In the most difficult exercises, students watch a filmed flight path along a designated route, which at some point deviates from the route. The student's task is to follow the filmed flight on a map and to indicate on the map where the flight deviated, where it went, and where it rejoined the route. It was reported

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[65]G. Holman. *Are You NOE and Lost?* US Army Research Institute for the Behavioral and Social Sciences, Fort Rucker, Alabama, 1975.

that this exercise was sufficiently difficult that experienced instructors became quickly lost and disoriented. If this instruction is effective in teaching NOE navigation skills which would transfer to actual flight, then it can be assumed that future operators will be able to arrive in the target area in a timely fashion and with a low radial miss distance. Data from US Army Combat Developments Experimentation Command (USACDEC) studies[66] indicate that a well-trained crew can duplicate the accuracy obtained with an onboard navigation system. The results of these studies showed a radial miss distance of ± 100 meters after navigating over a 30 km course. This error was obtained with an experienced, well-trained crew using dead reckoning and is about the same magnitude as was found in tests employing an onboard navigation system. It is not known if the more recently developed training will be effective in reducing this miss distance. This research indicates that for daytime engagements, the use of heavy and expensive navigational gear can be avoided.

NOE navigation accuracy under low-light conditions is an area of serious concern. However, an Electronics Command (ECOM) report[67] noted that visually-guided terrain following performance is not degraded under conditions of illumination ranging from full-moon to half-moon. However, as illumination levels were lowered further, degradation became apparent. Night vision goggles (PVS-5) allowed the pilot to function essentially

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[66] *Attack Helicopter - Daylight Offense, Volume II, Executive Summary.* Department of the Army, US Army Combat Developments Experimentation Command, USACDEC Experiment 43-6, Fort Ord, California, June 1972.

[67] *Low Level Night Operations Study, Summary Report.* Report ECOM-4212, Systems Engineering Team, Advanced Avionics System Technical Area, May 1974a.

unimpaired under conditions approximating quarter-moon illumination. It was further noted that training could develop a capability for low-light operations down to starlight levels of illumination. However, navigational efficiency was seen to decrease with conditions which decreased visibility, e.g., fog. In addition, it was noted that navigational accuracy increased with increased terrain clearance, which unfortunately increased exposure. Consequently, a recommendation was made in a second ECOM study[68] that an optimum strategy was to operate near an air speed which produced the best viewing rate for any given helicopter. Viewing rate as used here is primarily a function of helicopter power limitations, rotor characteristics, and the lag in response to control inputs. A second set of factors influencing viewing rate concerns the pilot's reaction time and willingness/unwillingness to execute high descent rates. As a result, maneuvers are generally executed well in advance of the terrain feature to be negotiated. All of this means that as speed in NOE approach increases, so does exposure.

Target Location Training

One of the central processes in target handoff seems to be an ability to effectively use visual and verbal information to locate a target. Powers, Brainard, Abram, and Sadacca[69] studied the effectiveness of two systematic search strategies *versus* free search in detecting targets

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[68] *Low Level Night Operations Study. Summary Report.* Report ECOM-4217, Systems Engineering Team, Advanced Avionics System Technical Area, May 1974b.

[69] J. Powers, R. Brainard, R. Abram, and R. Sadacca. *Training Techniques for Rapid Target Detection,* Technical Paper 242, US Army Research Institute for the Behavioral and Social Sciences, Arlington, Virginia, September 1973.

in photographic images. Results showed that while time to detection did not differ as a function of search strategy, the systematic search strategy resulted in more Type I errors (non-targets reported as targets). Error keys which identify likely non-targets may be of value in target handoff studies. By the same logic, it may be useful to develop a set of examples of terrain features which are poor reference points to accompany examples of good ones. Powers, et al., also investigated the differential effects between the two systematic search strategies. In the first of these, the "tactical" strategy, the subject was directed to attend to clues to the most *probable* target location. A second strategy involved a geometric search pattern designed to ensure that all areas of the image were searched. The tactical strategy resulted in greater error and longer search times than the geometric strategy. The tactical search strategy was also quite productive of Type I errors. However, this increased incidence of Type I errors may be a result of an interaction between the search strategy and the particular images used in the experiment.

As has been noted earlier, specific training in search has been productive of false positives or identification of targets that do not exist. Martinek and Sadacca[70] recognized this problem and proposed that "error keys be constructed for use by photoimage interpreters. The keys were constructed on the basis of typical interpreter error. Thus, the error key consisted of annotated photos showing typical errors with a short rationale concerning why the errors were made, and how they could be

[70] H. Martinek and R. Sadacca. *Error Keys as Reference Aids in Image Interpretation,* US Army Personnel Research Office, Support Systems Research Laboratory, June 1965.

avoided. Martinek and Sadacca then performed an experiment which compared the performance of three groups, one using both error and "right" keys, one with only the error key, and one with only the right key. Although there were no differences between the groups in their accuracy of correct identification, the use of the error key significantly reduced the incidence of incorrect identifications. With reference to the current effort, there is a possibility that an error key could be constructed which would result in more effective acquisition of terrain identification/description skills.

Levine and Eldridge[71] evaluated the effectiveness of providing ancillary information to a photoimage interpreter which would provide cues as to what to expect to find in the imagery. In their experiment, Levine and Eldridge presented information either during or after the interpretation task. The post-information was presented after the task and the subject was given an opportunity to revise his findings. A no-information condition was also included. The ancillary information was presented in either a qualitative (probability) or quantitative (numeric) mode. The authors concluded that the mode of information presentation did not make much difference. And, in general, it did not make much difference if the information was presented during or after the task. However, ancillary information was found to be effective in enhancing the ability of photoimage interpreters to identify targets. Further, these investigators noted that if target suggestions are provided by external sources, the number of these suggestions should be kept to a minimum. This observation may

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[71] J. Levine and D. Eldridge. "Effects of Ancillary Information Upon Photointerpreter Performance," *Human Factors*, 1972, 14(6), 549-560.

provide a hypothesis to account for the observed inefficiency of longer target location messages in target handoff.[72,73,74] These workers may also have committed a serious omission in not studying the effects of erroneous or incomplete information. The effects of ancillary information on production of Type I error might also be of interest.

Taylor, Eschenbrenner, and Valverde[75] proposed a traditional training development approach to improving FAC performance. Initially, these researchers analyzed the FAC visual reconnaissance task and also defined the stimulus characteristics of a specific variety of targets. This analysis was used as the basis for a training development effort aimed specifically at improving the visual orientation skills of FACs. The prototype training program featured a programmed text containing sketches and photos of targets with integrative text and materials. Taylor, et al., emphasized the cognitive and problem-solving aspects of the FAC's job in effective target detection. They proposed a two-phase model of visual detection: (1) a predecisional phase in which the observer builds a memory image of an area as a frame of reference for evaluating real-time perception, and (2) a decisional phase in which the observer compares aspects of the current scene with the memory image. This basic model can

[72] J. Morrissette, *op. cit.*

[73] M. Siskel and R. Flexman, *op. cit.*, 1962.

[74] A. Siegel and P. Federman, *op. cit.*, 1973.

[75] C. Taylor, A. Eschenbrenner, and H. Valverde. *Development and Evaluation of a Forward Air Controller (FAC) Visual Training Program*, Technical Report AFAL-TR-70-190, Air Force Avionics Laboratory, Wright-Patterson AFB, Ohio, September 1970.

be described as an internal perceptual comparison of "things as they were" *versus* "things as they are."

In a later phase of this work, Taylor, et al., evaluated the prototype course by comparing the performance of individuals so trained with individuals trained conventionally. This evaluation indicated that individuals who received the prototype instruction were superior in:

1. Developing a memory image of a local area.
2. Detecting subtle changes in terms of a given area.
3. Identifying potential targets.

Aume[76] studied the usefulness of a simple reticle in producing accurate estimates of target location. To use the device, a reference point must be selected and a reference distance specified. Target location was estimated in terms of clock heading from the reference point and distance in terms of ratio of the reference distance. The sighting device was, however, not superior to unaided eye using this technique. In addition, the technique is likely to be useful only if the handoff is from air-to-air. The perspective difference between ground observer and air are probably too great to allow the selection of a reference distance that is useful from both ground and air.

Federal Aviation Administration (FAA) Selection Research

The Federal Aviation Administration (FAA) has carried out considerable research on the correlates of job performance in the Air Traffic Controller's (ATC's) job. While the ATC job is conceptually different from that of the

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[76] N. Aume. *A Two-Reference-Point Procedure for Locating a Target*, AMRL-TR-72-90, Aerospace Medical Laboratory, Aerospace Medical Division, Wright-Patterson AFB, Ohio, May 1973.

individual performing target handoff, there are certain elements in common, i.e., the importance of accurate communications and the importance of timeliness. Spatial visualization may be another skill that is important in both jobs.

Cobb, Nelson, and Matthews[77] found significant inverse relationships between chronological age at entry and tenure in FAA ATC work. As a result, older individuals are transferred sooner to non-ATC positions. Younger individuals are effective longer in the ATC job and achieve greater tenure in *that job*. Examination of the partial regression coefficients showed that with experience held constant, age was the dominating factor adversely affecting job performance ratings. This finding is the latest of considerable work done in the relationships between age and performance in ATC work. Earlier work in this area includes that by Cobb,[78] Cobb, Lay, and Bourdet,[79] and Trites and Cobb.[80]

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[77] B. Cobb, P. Nelson, and B. Matthews. *The Relationship of Age and ATC Experience to Job Performance Ratings of Terminal Area Traffic Controllers*, FAA-AM-73-7, Federal Aviation Administration, Aeromedical Institute, Oklahoma City, April 1973.

[78] B. Cobb. *The Relationship Between Chronological Age, Length of Experience and Job Performance Ratings of Air Route Traffic Control Specialists*, FAA-AM-67-1, Federal Aviation Administration, Office of Aviation Medicine, Oklahoma City, 1967.

[79] B. Cobb, C. Lay, and N. Bourdet. *The Relationship Between Chronological Age and Aptitude Test Measures of Advanced-Level Air Traffic Control Trainees*, FAA-AM-71-36, Federal Aviation Administration, Office of Aviation Medicine, Oklahoma City, 1971.

[80] D. Trites and B. Cobb. *CARI Research on Air Traffic Control Specialists: Age, Aptitude, and Experience as Predictors of Performance*, Unnumbered Report, Federal Aviation Administration, Aeromedical Research Institute, Oklahoma City, 1964.

In an effort that may be of interest in further defining the target handoff problem, Thackray, Jones, and Touchstone[81] looked at performance impairment under distracting conditions. Thackray, et al, were particularly interested in the Stroop Color-Word Interference Test as a possible measure of the ability to attend simultaneously to certain stimuli in the presence of irrelevant and competing stimuli. Unfortunately, however, the investigators found no relationship between performance on the Stroop test and performance on a laboratory task requiring resistance to distraction. Thackray, et al., concluded that there is little support generated by this work for the existence of a general "distractability" factor. However, the ability to attend selectively to competing stimuli *may* be of importance in the performance of a realistic target description task.

Personality factors in ATC performance received a fairly thorough examination by FAA researchers. Korson and O'Dell[82] studied the relationship between several personality factors as measured by the 16 Personality Factor (16 PF) Questionnaire and job performance measures. In this study the 16 PF scores were correlated with performance as measured by the FAA Employee Appraisal Record (EAR) for non-supervisory employees. The EAR scale is a trait-oriented performance rating scale which exhibited small variability, at least in this particular work. Restriction of range of

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[81] R. Thackray, K. Jones, and R. Touchstone. *The Color-Word Interference Test and Its Relation to Performance Impairment Under Auditory Distraction,* FAA-AM-72-14, Federal Aviation Administration Institute, Oklahoma City, March 1972.

[82] S. Korson and J. O'Dell. *Performance Rating and Personality Factors in Radar Controllers,* FAA-AM-70-14, Department of Transportation, Federal Aviation Administration, Office of Aviation Medicine, Oklahoma City, September 1970.

the criterion variable, therefore, limited the magnitude of any correlation with the predictors. In a subsequent factor analysis, the job performance measures were seen to reside in their own, virtually, private factor. The overall pattern indicated a negligible relationship between job performance and the personality measures.

Standardized aptitude tests have a varied record as predictors of job success. However, their record is somewhat better as a predictor of success in training. Consequently, Cobb[83] looked at the relationships between aptitude test scores and success in ATC training. Specifically, Cobb was interested in the predictive efficiency of various aptitude tests against criteria of student performance at various steps in the ATC curriculum. Moderate prediction was reported with a composite of commercially available tests. The commercial tests were marginally superior to government aptitude tests in predicting course scores. The Differential Aptitude Test (DAT) and scales from the California Test of Mental Maturity (CTMM) were used to form the composite. Possibly, a more effective approach than that used by Cobb would be to start with an analysis of the basic information processing capabilities required of the successful trainee in the curriculum under study. The next step in this alternative approach would be to identify or develop measures of these capabilities, validate them, and then study their success in predicting job or training outcomes.

In a test of aptitude more closely tied to job performance, Chiles, Jennings, West, and Abernathy started by assuming that one of the required

[83] B. Cobb. *Air Traffic Aptitude Test Measures of Military and FAA Controller Trainees*, FAA-AM-71-40, Federal Aviation Administration, Civil Aeromedical Institute, Oklahoma City, October 1971.

elemental skills for a successful ATC is the ability to do several things simultaneously.[84] Chiles, et al., looked at the Multiple Task Performance Battery (MTPB) as a useful predictor of ATC performance. The MTPB was developed by a contractor for the USAF. Experienced instructors rated the MTPB highly as regards its similarity to the ATC task. The results of this study showed that the predictive power of the MTPB is greatest when performance is measured during initial skill acquisition, which might be expected as variability is greatest during acquisition. These investigators, however, thought the MTPB held sufficient promise as a predictor of ATC performance to merit further investigation. Unfortunately, this lead apparently was not followed, as no subsequent investigations are to be found in the literature relating MTPB scores to ATC performance.

Summary and Conclusions

It appears that Army training in target handoff does not exist and doctrine regarding target handoff is inadequate. In addition, the SOPs that were developed in SEA combat will almost certainly not generalize to any realistically foreseeable combat situation.

A small body of research was found which dealt with target handoff from airborne FAC, to high-performance USAF strike aircraft. This research dealt in depth with the problem of verbalizing visual imagery. The cognitive processes involved in selection and labeling terrain features were also given attention. This USAF research served as a stimulus for a further look into communications research and methodology. Very little

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[84] W. Chiles, A. Jennings, G. West, and W. Abernathy. *Multiple Task Performance as a Predictor of the Potential of Air Traffic Controller Trainees*, FAA-AM-72-5, Federal Aviation Administration, Oklahoma City, January 1972.

information which bears directly on the target handoff problem was revealed. However, some of the measures and methods from this work may be of use.

It was also observed that it is vital that the ground observer know, with a good degree of certitude, his own position before he can accurately describe a target area. A fair amount of research and practical instructional development was uncovered which dealt directly with this problem, e.g., land navigation, map use, compass use, azimuth estimation, and distance estimation. If this body of work were to be implemented in a coherent program of instruction, it should be possible to train the average individual to locate himself with high accuracy.

It is also important for the pilot of the fire-support aircraft to be able to move rapidly to the target area, and once there, be able to accurately locate the target. To this end, considerable research has been directed at low-level navigation with the result that the skills and knowledges for low-level navigation have been well defined. Training programs have been developed which will give navigational accuracy that is close to that obtained with sophisticated navigational systems. Low-level night flight, particularly at high speeds, however, remains a problem -- improved night vision devices or sophisticated navigational systems may be required for effective night engagement.

Finally, a body of work dealing with ATC performance was cited. Several of the studies performed by the FAA have application to the target handoff problem. Attempts to predict performance in the ATC job have been generally unsuccessful. This lack of success is most likely due to an unclear conception of the processes involved in the job, as

well as a lack of a suitable performance criterion. The shortcomings of this FAA work suggest that research defining the target handoff should be focused at obtaining an understanding of the behavior of individuals functioning in the act of handing off a target.

It is possible, from the preceding, to construct an avenue of approach for research into the target handoff problem. The initial effort must be directed at defining the behavioral components of the task. It is apparent from the review that the processes of mental imagery and associative learning are dominant in effecting a useful target description -- or location. The pilot, naturally, interprets the observer's description of the scene in terms of his own experience. When asked to locate a target with reference to terrain features, he will call up a memory image of the feature, which may or may not be in consonance with the image held by the observer. In addition, while mental images may be easily manipulated, visualizing an object as it may appear from a different orientation is difficult for many people, although there is evidence that appropriate training or selection may be effective in improving this performance.[85,86] This imagery of the target and its location must then be transformed into verbal form for transmission to another individual. The task at this stage becomes one of information exchange between the cooperating individuals in an attempt to reach an accurate and timely solution. The manner in which this information is exchanged and how feedback is provided is critical to successful handoff.

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[85] G. Bower. "Mental Imagery and Associative Learning," in L. W. Gregg (ed.), *Cognition in Learning and Memory*, New York: John Wiley and Sons, Inc., 1972, pp 51-88.

[86] E. Brinkman, *op. cit.*, 1966.

The first priority in the further study of target handoff is to establish a situation in which it is possible to observe the handoff task actually being performed. It should then prove very fruitful to compare the performance of individuals performing successful *versus* unsuccessful handoffs. Among the questions which might be answered are:

1. What features are used as reference points to target location?

2. What characteristics distinguish a feature that is useful as a reference point?

3. What sort of strategies are used to progressively relate features to the final target location?

4. What are the language characteristics of the handoff message:

   a. What sort of landmark labels are used which are more effective?

   b. What is the optimal sequence of message events?

   c. What is the role of feedback and acknowledgment?

   d. What is the minimum effective message -- what components are important?

   e. What message rates are optimal?

   f. What voice fundamentals are most intelligible?

   g. What is the effect of regional pronunciations on communication?

   h. Are relative measurement units more effective in communicating distance than conventional units?

   i. Are compass headings more effective than clock headings?

5. Does simple unguided practice in handoff result in improved performance?

6. What training strategies result in optimal skill acquisition:

a. Can simulation provide adequate training?

b. What are the characteristics of a useful low-cost simulation?

7. What are the characteristics of the fast learner?

8. What are the characteristics of the good performer?

This list of potentially researchable questions is not intended to be exhaustive, and others will likely surface as data are gathered on individuals performing target handoff.

As a final note, as is quite often the case, the literature review turned up many more questions than answers. The review was, however, successful in providing a focus for research on target handoff by discovering which variables may be important for future research and which may be safely ignored. In addition, the findings of the review will be useful in establishing priorities for the direction of the target handoff research.

CHAPTER 3

THE TARGET HANDOFF QUESTIONNAIRE

Army doctrine, tactics and training were examined as part of the literature review effort. This effort revealed that this documentation shed very little light on existing target handoff procedures. From the review, it was evident, in fact, that local unit SOP was the basis for most target handoff procedures. Therefore, it was deemed necessary to acquire information concerning those existing target handoff procedures, particularly under combat conditions.

Accordingly, a letter was prepared which was intended to identify individuals with combat handoff experience and distributed to officers in grades 03 through 05 and CW3 and CW4 at HQ MASSTER, West Fort Hood, Texas. Eighty-five individuals were identified who had either initiated or received a target handoff. Initially, contact was made with five of the respondents who had either indicated special interest or who reported extensive experience. These individuals were informally interviewed to obtain a general picture of:

- What targets were handed off,
- What the nature of the handoff message was,
- What problems were encountered,
- What target marking methods were used,
- What typical AH tactics were employed.

The interviews revealed a considerable difference in individual experience, although all of the officers interviewed had obtained their target handoff experience in Southeast Asia (SEA).

On the basis of the wide variety of experience reported by the initial small sample, it was decided to obtain information from the remainder of the group reporting target handoff experience. It was felt that the questionnaire would provide valuable information on three topics:

. What handoff techniques were in use,

. What problems were encountered,

. What the typical mission profile was.

It was felt that this information concerning current techniques and problems could be used to structure improved techniques as well as to devise hypotheses for future research. The average mission profile information was intended to provide a basis for building a simulation which would allow intensive study of the target handoff task.

A questionnaire was prepared, using the information obtained from the interviews to form the basis of the items. This questionnaire was initially drafted and revised several times with the cooperation of the contract COTR. Finally, a two-part instrument was devised; one part intended to be answered by Attack·Helicopter (AH) pilots or airborne observers, the other part by individuals who had handed off a target to the air. This version was then given to an officer with considerable handoff experience for review and comments. This review was intended to ensure that proper Army terminology was used throughout and that the questions clearly communicated the intent of the research. The reviewer's comments were extensively discussed with him and the final form of the questionnaire incorporates these comments. The questionnaire is included in this document as Appendix A.

Eighty questionnaires were sent 15 December 1975 with a one-month suspense. As of the suspense date, 42 returns had been received from individuals who had handed off targets from ground-to-air. However, only 11 questionnaires were returned by individuals with experience as either a pilot or observer in an AH. Therefore, a means was sought to remedy the imbalance in sample size between the two groups. Contact with the ARI Field Unit at Fort Rucker, Alabama, revealed that a sample of combat-experienced AH pilots had been identified for the purposes of other research. Accordingly, a number of questionnaires were sent to ARI, Fort Rucker, for distribution to these individuals. This effort yielded a total of 15 additional questionnaires from individuals who had received a handoff from the ground.

Results

Because the two sections of the questionnaire contain a slightly different set of items, it is appropriate to discuss them separately.

The results of Part I of the questionnaire will be described first. As noted earlier, 42 respondents completed this portion of the questionnaire and returned it.

Part I Results

Item 1 requested that the respondent briefly describe the situational essentials of his past handoff experience. Included were such factors as: unit, function within unit, geographical setting, and time frame. Following is a breakdown of the respondent sample in terms of unit and function (see Table 1).

The function of *advisor to an ARVN* (Army of Republic of Vietnam) *Unit* was reported most often with *infantry company commander* second. It is not

Table 1. Respondent Experience

Unit/ Function	Number of Respondents Reporting
Infantry Platoon Leader	4
Infantry Company Commander	8
ARVN Advisor	22
G3 Air Operations	1
Armored Cavalry Troop Commander	1
Armored Cavalry Forward Observer	2
Infantry Battalion S3	6
Infantry Battalion S2	1
TOTAL	45*

***This number reflects varied duties within a tour of dates and that several respondents had more than one tour of duty in SEA. Hence, the sum is greater than the number of respondents.**

likely that the experience of serving as an advisor, with many relatively undefined responsibilities will yield information that will generalize to a future conflict. In addition, it can be questioned if these experiences are even typical of SEA experience. With regard to time frames, the bulk of the advisors served in the 1964-69 time period. The individuals serving in other capacities generally received their experience in the time frame 1967-72. Thus, the responses to this portion of the questionnaire can be thought of as representing the responses of samples drawn from two populations with quite different combat experience. However, since the same individual might have served during both time periods, it was not considered feasible to report the results separately.

With regard to attempted handoffs, the group reported a mean of 34.31 handoff attempts (Standard Deviation [SD] = 42.07), of which 76.53 percent were successful (SD = 26.03). Little communication difficulty was indicated, but clarification was requested 7.99 percent of the time (SD = 16.04). Evidence for considerable variation in experience was shown by the large SDs associated with these figures. Throughout the questionnaire the SDs are generally larger than the means with which they are associated.

With regards to methods of target designation, the most popular method was *verbally, by range and direction from a known point* (mean percent = 28.81, SD = 22.81). The next popular method involved the *use of grid coordinates* (mean percent = 26.02, SD = 31.62). This method was followed in popularity by *range and direction from smoke* (mean percent = 20.23, SD = 21.24). A very small percent reported the *use of panels, tracers, flares and assorted idiosyncratic techniques*. When grid coordinates were used, 29 percent reported they were always accurate, while 59 percent said

they were accurate most of the time. Only 8.0 percent reported them as being accurate some of the time. Three percent reported that they never used grid coordinates. This confidence in the accuracy of coordinate information may reflect that the respondents were being asked to judge their own map reading ability. Additionally, it is not known what criterion the respondents used for judging their accuracy. It will be interesting to contrast this impression of accuracy with the responses of the pilot group who actually had to use the coordinates.

With regard to terrain features used as reference points in target designation, Table 2 summarizes the categories of reference points, their frequency of use, and perceived importance.

Lake shores, streams, and canals were used most often as reference points with *mountain tops and hilltops* a close second. However, mountain tops and hilltops were ranked as most useful more times than any other feature. The third most popular feature was a *treeline or woodline*. *Highways, roads, or trails* followed in number of mentions. All of the other features were used as reference points few times.

Features used as reference can be further logically categorized as point, line, or area, each of which can be either man-made or natural. Nine of the features mentioned are classifiable as "lines," e.g., stream, woodline. Of these, four are man-made, e.g., railroad. Line features account for 63 of the total mentions, or 51 percent. An additional nine of the features can be categorized as point features (e.g., road junction, stream confluence). Four of these point features are man-made. Point features were mentioned 30 times, or 23 percent. Eight area features appeared (e.g., tree clumps, patch of vegetation) which also account for 30

Table 2. Reference Points Used by Ground Observers

Feature	No. of Mentions	No. of Times Ranked 1	2	3	4	5	6
Cultivated Field	2			1			1
Village	8	2	2	1	2	1	
Highway, Road, Trail	11	1	6	2	1	1	
Lake Shore, Stream, Canal	25	10	9	3	3		
Treeline, Woodline	18	8	4	4	2		
Rice Paddy	2					2	
People (Individuals)	1						1
Mountain Top, Hilltop	22	13	5	2	2		
Contours	1	1					
Tree Clumps	1	1					
Buildings	8	2	1	3	2		
Clearings	5		1	4			
Bridges	2		1		1		
Own Location	1	1					
Ridgeline	3		1	2			
Valley	2	1				1	
Railroad	1					1	
Stream Crossing (Ford)	1	1					
Road Intersection	5	3		2			
Tree (Single)	5	1	3		1		
Rock Outcrop	1		1				
Draw	1			1			
Stream Confluence	2	1	1				

Table 2 (continued)

		1	2	3	4	5	6
Patch of Vegetation	1				1		
Shrine	1			1			
Bomb Crater	1		1				
Bend in River	1				1		
Village Wall	1				1		
TOTAL	132						

mentions, or 23 percent. Five of the area features may be considered as man-made. Further, the great majority of all of the features mentioned have the essential characteristics of being recognizable when viewed from the air. These features are characterized by extent rather than by height and, therefore, are useful for directing an airborne observer. It is not known, however, how much the meanings of the terms used overlapped. Additionally, the range of physical objects which could be described by any single term is not known.

Of the respondents, 36.53 percent (SD = 32.11) *found it difficult to give the AH pilot a complete briefing;* 17.47 percent (SD = 19.39) *found it difficult to get the AH to see the target by referencing the target's location to a known point.* Finally, 22.36 percent (SD = 29.25) *found it difficult to get the AH to see the target by directing its maneuvers.* Again, the large variance associated with these means probably reflects variety in the experience or response sets of the subjects reporting. The distribution of actual responses to these three items is essentially bimodal with one group reporting little or no difficulty, and another who experienced considerable difficulty. As an example, examination of the 32 responses to Item 9a (difficulty in giving a briefing) revealed that 15 (44 percent) responded that it was *difficult from 0-25 percent of the time,* while 11 (34 percent) experienced *difficulty from 75-100 percent of the time.* Thus, although it is not reflected by the means for these items, a substantial amount of difficulty was experienced in briefing the pilot, vectoring him to the target using a reference point, and directing the AH's maneuvers.

The next item required the respondent to report the percentage of missions during which he encountered a specific problem. Nineteen problems were listed as shown in Table 3.

The most salient aspect of this data is the generally small percent of time a specific problem was encountered and the large variances commonly associated with the means. The large variance in this instance is probably due to the large number of 0 percent responses, causing the distribution of responses to assume a positive skew. As an example, in response to Item a (see Table 3), 21 individuals reported encountering the problem on 0 percent of their missions. Eleven individuals reported encountering the problem in 01-10 percent of their missions, while only five reported encountering a problem 10-50 percent of the time. Despite the small mean (15.85 percent) associated with *unnecessary chatter* (Item c), seven respondents (N=41) rated chatter a problem 33-100 percent of the time. Therefore, it appears that there are instances of misuse of radio channels which may interfere with the capability to carry out close-air support.

Item e *(lack of a prominent landmark)* was reported as a problem 30-90 percent of the time by nine out of 41 respondents. This problem is probably unique to SEA experience, where large areas of terrain are covered by a double-canopy jungle with few prominent features. This unique terrain is probably the cause of the high incidence of reporting the *target obscured by foliage* (Item j). A relatively high number of the respondents also reported that the *pilot often confused an intended terrain feature with another*. The frequency that this was a problem ranged from 0-100 percent. Again, when this was reported a problem it may have been a result of the

Table 3. Incidence of Specific Problems (Ground Observers)

Problem Area (Brief)	Difficulty Reported (%)	SD
a. Inappropriate, unfamiliar or confusing terminology	7.46	12.89
b. Confusion or error in changing call signs	6.63	17.74
c. Unnecessary chatter	15.85	26.79
d. Poor enunciation over voice channels	7.07	17.17
e. Lack of prominent landmarks	17.83	23.31
f. Misunderstood or miscopied coordinates	3.34	5.57
g. Pilot confused terrain	12.49	19.92
h. Strike AH at wrong location	2.15	3.97
i. Strike AH arrived too late	13.49	21.29
j. Target obscured by foliage	41.9	33.98
k. Wrong target marked	1.75	3.97
l. Smoke markers confused with other smoke	7.63	17.58
m. Could see targets but AH could not	11.95	18.79
n. Strike pilot could not understand description	6.85	18.60
o. Pilot could not see orienting feature	4.52	9.31
p. Ground judgment of target range differed from airborne	12.59	20.01
q. Pilot ignored orienting instructions	3.27	10.60
r. Strike on wrong azimuth	4.52	15.91
s. Corrections on fire not understood by pilot	5.34	17.56

relatively homogeneous jungle terrain encountered in SEA. A number of individuals also reported that the *AH arrived too late* (Item i). Eight (N=41) of the respondents reported this as a problem from 25-100 percent of the time. Since one of the supposed advantages of Army air is its quick reaction time, this respone indicates the existence of a problem in the system. There is, unfortunately, insufficient information at this time to isolate the source of this problem.

It was also reported that the *judgment of distance by the individual on the ground was different from the individual in the air* (Item p). Twenty-two individuals reported this as being a problem some percentage of the time, while six individuals reported it as a problem 25-100 percent of the time. Actually, some difference in range estimation is to be expected between any two unselected individuals. Given the difference in perspective between the ground and air positions, it is remarkable that differences in range judgment was not reported as a problem more often. The most likely reason for this is that differences in range estimation between individuals would only be noted if it resulted in an error in target location. Apparently, this did not happen too often.

Item 11 on the questionnaire listed six possible training content areas (see Table 4 for a description of these areas) and requested that the respondent rank them in terms of how much training emphasis they should receive. The respondent was further instructed to consider his rankings with regard to a future mid-intensity conflict. Table 4 below gives the mean rankings and SDs for each of the six content areas.

Overall, there seems to be good agreement by the respondents that *specific training in handoff and map reading* would be desirable. Seven-

teen respondents ranked handoff training first, while an equal number ranked map reading as first. However, as was noted in the literature review, map reading has been well studied and advanced training materials currently exist. It was also noted in the review that there has been no work in the development of training in ground-to-air or air-to-ground handoff procedures. First priority should, therefore, be accorded training in handoff and, in fact, one of the ultimate goals of the target handoff research is to develop improved procedures which may include training development. The other possible training areas appear to cluster in perceived importance somewhat below handoff and map reading. Hence, it appears that at least in the judgment of these respondents, training development efforts would best be spent on improving map reading and target handoff skills.

Table 4. Rankings of Possible Future Training Content (Ground Sample)

Content Area	Mean Rank	SD
a. Specific Training in Handoff Procedures	2.16	1.21
b. Improved Target Marking Procedures	3.48	1.72
c. Improved Prestrike Briefing	4.44	1.31
d. Compass Use	4.23	
e. Map Reading	2.29	1.38
f. Contour Interpretation	4.21	1.69

Seven items (see Table 5 below) on the questionnaire concern the parameters of target range and AH position. It was intended to use this information to develop a typical mission profile. This mission profile could then form the basis for a scenario for a simulation of a target handoff mission. Unfortunately, examination of the data in Table 5 reveals that there was much variation in all of the mission parameters. Hence, it would not be legitimate to select any particular range-to-target or helicopter position as "typical." Some other source must therefore be identified upon which to model the simulation.

Table 5. Mission Profile Data (Ground Sample)

	Item Description	Mean	SD
a.	Range of distances from observer to target (m)*	186-1250	262-996
b.	Usual distance from observer to target (m)	461	398
c.	Range of distances from observer to AH at initial contact (m)	2586-14023	4146-16236
d.	Typical distance from observer position to AH at initial contact (m)	9330	9870
e.	Percent AH arrived over observer position	55.54	35.56
f.	Range of distance between observer and AH when AH arrived in target area (m)	580-1907	122-1907
g.	Typical distance between observer and AH at AH arrival in target area (m)	1028	1042

***The means and SDs shown for items requesting ranges are given with the statistic for the lower estimate first.**

Table 6 summarizes the targets typically attacked in the combat experience of the respondent sample. The table shows both the number of times a particular target was engaged, as well as the relative frequency of engagement. Examination of tabled data reveals that *bodies of troops* were reported as frequently engaged by the largest number of respondents. Next in mentions and frequency were reports of attacks against *bunkers and dug-in positions*. *Engagement of enemy weapons positions* came next, followed by *suspected enemy positions*. In the latter case, a probable enemy position was concealed from view and the general tactic was to cover the area with gunfire and rockets. Various other targets were encountered infrequently and by only a few of the respondents.

It is not known to what extent this pattern of attack will resemble any future conflict. It is apparent though that these data reflect a rather profligate expenditure of resources against targets that could probably be handled more economically by other means.

Part II Results

Pooling the questionnaires returned at MASSTER with the Fort Rucker returns resulted in a total of 25 respondents. Of this number, six received their experiences as observers in an AH, while six served as AH pilots. An additional 13 of the respondents had experience as both an observer and as a pilot. Table 7 below details the experience of the respondent group.

The data in Table 7 indicate that this group has extensive experience in providing close-air support to ground elements. As a group, they exhibit much more experience at receiving handoffs than the ground group in initiating handoffs. The percent success reported by the two groups

Table 6. Types of Targets Engaged

Feature	Individuals Mentioning	Relative Frequency 1	2	3	4	5	6
Troops (Moving)	37	22	5	7	2	1	
Bunkers, Dug-in Positions	27	10	12	3	2		
Weapons Positions	17	5	7	5			
Villages, Houses, Buildings	3			2	1		
Covering Fire	1				1		
Armor	3			1	1		1
Suspected Enemy Location	7	1		3	3		
Convoys	2			2			
Sniper	1	1					
Way Station	2		1		1		
Ambush Site	1				1		
Vehicles (Individual)	1		1				
Communications Station	1		1				
Enemy Headquarters	2	1				1	
Boats	2	1	1				
Tunnels	1				1		
TOTAL	108	40	28	24	13	2	1

is, however, similar. The experience of the air group was less varied as reflected by the smaller SDs associated with their mean responses.

Table 7. Respondent Experience

Item	$\bar{x}$ Response	SD
1. Number of pilot missions	613.8	682.2
2. Number of observer missions	489.0	514.6
3. Number of handoffs received	337.6	339.3
4. Estimated percent success	80.34	15.18
5. Number of handoffs to ground	78.3	102.8

Handoff to ground elements from air was reported to have occurred a mean number of 78.3 times (SD = 102.8). The respondents were not asked to estimate percent success, as interviews with experienced individuals indicated that the pilot or observer would be unlikely to have direct knowledge of the success of the resultant ground engagement.

The pilots and observers reported that *unintelligible communications interfered with mission success* 7.05 percent of the time (SD = 11.08). Similarly, they reported that it was necessary to *ask for clarification* 31.15 percent of the time (SD = 20.04). These percentages are larger than those reported by the ground group and probably reflect the greater need for precision in language by the AH pilot or observer. The observer or pilot is the "doer" and as such, his effective performance requires that the ground observer or "knower" provide precise and useful information; hence, the larger number of requests for clarification.

With regard to methods of target designation, two were used nearly equally as often; *smoke and White Phosphorous (WP)*, 41.4 percent (SD = 35.29),

and *verbally, by range and direction from smoke,* 41.52 percent (SD = 32.33). The use of *range and direction from a known point* was used 25.04 percent of the time (SD = 25.97) followed by *verbal directions with grid coordinates* (mean percent = 18.32, SD = 20.1). A very small number reported the *use of panels or other methods of designating the target.* These data stand in contrast with the reports of methods used by the individuals who have handed off from ground. These individuals reported that the most popular method was *range and direction from a known point,* followed closely by the *use of grid coordinates.* No informed conjecture can be made at this time concerning these differences in method of target location.

When grid coordinates were used, the pilots and observers reported that 77 percent were accurate "most of the time" and 23 percent reported that the grid coordinates were accurate "some of the time." The pilots and observers were then somewhat less optimistic as to the accuracy of grid coordinates than the individuals with ground experience. Since the pilots and observers were in the position of having to use the coordinates given them by the ground observer, perhaps their perception of accuracy is more correct.

Table 8 summarizes the terrain features which were used as reference points in target designation. The table is similar to Table 2 and summarizes the categories of terrain used and their perceived importance.

Lake shores, streams, canals, etc., were used most often, with *mountain tops and hilltops* second. *Treelines and woodlines* were the third most popular feature in target designation, while all other features were mentioned only a few times. This pattern of response is almost identical to that of the ground observer group. Thus, there seems to be good agreement as to what consistutes a good reference point for target location.

Table 8. Different Points Used by Pilots and Observers

Feature	No. of Mentions	No. of Times Ranked 1	2	3	4	5	6
1. Cultivated Field	6	1	1	2	1	1	
2. Village	4	3		1			
3. Highway, Road, Trail	4	1	1		1	1	
4. Lake Shore, Stream, Canal, etc.	21	4	8	3	3	2	1
5. Treeline and Woodline	10	2	3	2	2		1
6. Rice Paddy	2		1	1			
7. Mountain Tops and Hilltops	17	5	6	3	1	1	1
8. Tree Clumps	3						3
9. Buildings, Houses	5		1	1	2	1	
10. Clearings	2				1	1	
11. Ridgeline	1					1	
12. Valley	3		1	1		1	
13. Stream Crossing (Ford)	2			2			
14. Road Intersection	5	1	2	2			
15. Patch of Vegetation	2			1		1	
16. Bomb Crater	2	2					
17. Bend in River	1		1				
TOTAL	90						

As was done with the ground observer responses, the features used for reference were categorized as point, line, or area. Features were then further categorized as natural or man-made.

Five of the features mentioned by the pilots and observers are classified as "lines," i.e., *streams, treelines,* etc. Of these, one is clearly man-made, i.e., *highways or roads.* Line features accounted for 37 of the total mentions, or 41 percent. An additional four of the features mentioned can be categorized as point features (e.g., *road intersections, hilltops).* Three of these point features are man-made. Point features were mentioned 26 times, or 29 percent of the total. Eight area features were mentioned (e.g., *clearings, villages, fields,* etc.). Four of the area features are classifiable as man-made. Area features account for 27 mentions, or 30 percent. Again, the categories of features used by the respondents, and the number each was mentioned, is strikingly similar to the responses of the ground observer group.

In responding to Item 13, 10.22 percent (SD = 19.37) of the respondents reported a problem in *navigating to the target area,* while 36.90 (SD = 30.90) experienced difficulty in *locating the target once in the target area.* Seven of the 25 (28 percent) respondents completing this latter item reported difficulty from 50 to 100 percent of the time. Therefore, it appears that target location was a substantial problem for a significant number of the pilot and observer respondents. It should be remembered that these difficulties were encountered in a combat situation that imposed few limitations on methods of target designation. Additionally, in SEA, where the enemy had little effective air defense, the AH had nearly unlimited search time. It can be expected that, faced with doubtful air superiority

and an enemy equipped with modern air defense equipment, that target location difficulties will show a sharp increase.

The next item (14) requested that the respondents estimate the percentage of missions on which they had encountered a specific problem. Fifteen problems were listed. Table 9 summarizes the responses of the pilot and observer sample to Item 14.

These results may be usefully compared to those obtained from the ground observer sample (Table 3). Despite the smaller pilot and observer sample, the SDs associated with the mean responses are generally smaller than those obtained from the ground sample. Presumably, this smaller variance reflects a more uniform experience on the part of the pilots and observers. Whatever the cause, responses by the pilots and observers to the items show a smaller incidence of skewed and bimodal distributions than the responses of the ground observers. Additionally, this group identified fewer areas as having caused a problem than the ground sample.

Inappropriate or confusing terminology (Item a) was reported as a problem on a small number of missions, while *poor enunciation* (Item d) was encountered somewhat more often. *Unnecessary chatter* (Item d) appears to pose a fairly serious problem or at least is of greater concern to the respondents in this sample.

Lack of a prominent terrain (Item e) was encountered about as often by the pilots and observers as by the ground respondents. The pilots, however, reported that they *confused terrain features* less (Item h) than was reported by the ground observers. Both groups of respondents, however, encountered *targets obscured by foliage* about as often.

Methods of target designation also caused problems on some missions as indicated by the responses to Item j (*wrong target marked*) and Item k

Table 9. Incidence of Specific Problems (Pilot and Observer)

Problem Area (Brief)	Difficulty Reported (%)	SD
a. Inappropriate, unfamiliar or confusing terminology	9.52	8.20
b. Confusion or error in changing callsigns	11.69	20.48
c. Unnecessary chatter	27.38	28.44
d. Poor enunciation over voice channels	14.44	14.49
e. Lack of prominent landmarks	16.17	16.88
f. Misunderstood or miscopied coordinates	6.21	5.26
g. Given an incorrect heading	6.87	7.82
h. Confused intended terrain feature with another	8.20	9.60
i. Target obscured by foliage	42.95	27.80
j. Wrong target marked	8.61	18.09
k. Smoke markers confused	8.83	18.67
l. Ground judgment different from airborne	20.00	17.66
m. Inaccurate heading	8.45	10.78
n. Unfamiliar description of terrain	8.84	12.12
o. Ignored orienting instructions	3.53	6.42

(smoke confused). The large SDs associated with these means are a function of a relatively large number of "zero" responses to the item. Responses to Item k ranged from 0 to 80 percent, with seven zeros (38 percent). Unfortunately, it is not apparent from available information why some individuals encountered difficulty on a substantial proportion of their missions, while others reported no difficulty.

As reported by the ground observers, it was also noted that *ground judgment of distance* was periodically different from that of airborne observers (Item c). The comments made earlier with reference to the response of the ground sample also apply here -- apparently the only time the difference in judgment of distance was noted was when an error in target acquisition occurred. While distance estimation by airborne and ground personnel should have differed fairly often, apparently, the discrepancy was within limits which would allow target acquisition. Again, in a more intense combat situation, this difference in range estimation may emerge as a source of real difficulty.

Misunderstood or miscopied coordinates (Item f) was not encountered too often. Similarly, the incidents of the pilot *ignoring orienting instructions* (Item o) were encountered relatively rarely.

Item 15 on the airborne questionnaire listed six possible training content areas and requested that the respondents rank them in terms of the training emphasis each should receive. This item was identical to Item 11 on the ground questionnaire. Table 10 gives the mean rankings and SDs for these training content areas.

Unlike the ground sample (see Table 4), these respondents felt that *contour interpretation* was the most deserving of training emphasis.

Map reading was ranked next, while *special training in handoff procedures* was third. The two groups shared their concern for map reading but did not agree as to the importance of handoff training. This pattern of response might change if the instructions for this item included information as to who was to be trained. However, the air sample apparently felt that it could use more training in map reading and contour interpretation. These responses probably reflect their realistic concern with accuracy in NOE flight. As was noted in Chapter 2, NOE navigation is often difficult for a variety of reasons. One source of difficulty is certainly map interpretation, which is at least partially due to the small scale (1:250,000) map used in aircraft. Contour interpretation on these maps is also a very difficult task. Low priorities were placed by both groups on *compass use* and *improved target marking facilities*, while the air group considered *training in prestrike briefings* to be more critical.

Table 10. Rankings of Possible Future Training Content (Air Sample)

Content Area	Mean Rank	SD
a. Special Training in Handoff Procedures	3.09	1.68
b. Improved Target Marking Procedures	3.43	1.59
c. Improved Prestrike Briefings	3.21	1.81
d. Compass Use	4.32	1.52
e. Map Reading	2.52	1.47
f. Contour Interpretation	2.30	1.80

The final 11 items were intended to supplement the ground information on mission parameters. This information (see Table 11 below) was largely concerned with AH tactics in approaching the target area and was intended to be combined with mission data from the ground observers to derive a model of a typical mission profile. Unfortunately, as was the case with the data obtained from the ground respondents, great variability in responses was very evident. Information from local sources at Fort Hood indicates that an appropriate mission profile could feature NOE flight, relatively high speeds (50-75 kts) and arrival in the target area at a position other than over the observer's position. In addition, target acquisition must be rapid and occur as the AH "pops up" from behind cover. Thus, the navigation to the target area must be accurate and the method of target designation must allow very rapid acquisition of the target if the AH is to survive.

Table 11. Mission Profile Data (Air Sample)

Item Descriptors	Mean	SD
Range of distances from ground-to-target*	81.05 - 921.05	82.97 - 775.01
Typical distance	268.75	316.74
Range of distances from initial contact to target	1473.33 - 6546.67	2229.1 - 5932.1
Typical distance	2485.88	3168.24
Range of altitude (feet)	869.71 - 2254.21	4423.87 2393.71
Typical altitude (feet)	1379.93	3779.22
Ranges of speed in approach (kts)	67.20 - 125.32	40.25 - 41.03
Typical speed	97.31	31.10
Percentage of arrival over observer's position	64.24	31.14
Range of distances between AH and observer's arrival	476.65 - 2985.71	793.3 - 4038.63
Typical distance	691.18	451.47

*** The means and SDs shown for items requesting ranges are given with the statistic for the lower estimate first.**

CHAPTER 4

SIMULATION AND TRAINING

The achievement of a detailed understanding of the target handoff task requires that the task actively be observed while it is being performed. Because of the great cost involved, it would not be feasible to stage a realistically simulated engagement with handoff. Additionally, it would not be possible to "stop" the action in such an engagement to question a particular action. Consequently, it was decided to develop a simple simulation which would allow access to the handoff task as it is being performed.

There are other reasons for developing a simulation. Simulation provides an excellent environment for training personnel to function effectively in a system. Many of the variables in the learning environment may be controlled. In addition, the instructor has immediate access to the behavior under instruction and can provide adjustments in the experience and give feedback as required. Thus, the trainee can receive immediate knowledge of results without the detrimental effects of performing incorrect actions. Additional advantages of using simulation are:

a. Control over time. Simulation can be used to speed up the rate at which events unfold or slow them down. A rate can generally be selected which will be amenable for the particular methods of observation being used.

b. Precise control over situational and experimental factors. This advantage in control allows the experimental examination of factors which are important to the goals of an experiment without contamination from undesirable sources of variation.

c. Ability to perform a relatively unlimited number of replications when it is desirable to do so.

d. Simplification of the complex environment within which handoff normally occurs. It will allow the isolation and extraction of the most relevant variables for incorporation in the training.

It is intended that the observations made under simulated conditions transfer and apply to the real world. Since the ultimate goal of this research is to provide improved target handoff procedures that will be useful in combat, defining the conditions of transfer is very important. The degree of transfer appears to be directly related to *fidelity*, or the extent to which the simulation represents the real world situation.

The fidelity of simulation is composed of both physical and psychological dimensions. Physical fidelity refers to the extent to which the simulation represents the environment and equipment characteristics of the real situation. Conversely, psychological fidelity concerns the degree of similarity between the psychological demands of tasks in the simulation and in the real world. A number of researchers have concluded that psychological fidelity is more important for adequate transfer than physical fidelity.[1,2,3,4,5] In fact, there is some evidence that too

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[1] J. Cox, R. Wood, L. Boren, and H. Thorne. *Functional and Appearance Fidelity of Training Devices for Fixed-Procedures Tasks*, HumRRO Technical Report 65-4, Human Resources Research Organization, Alexandria, Virginia, June 1965.

[2] D. Grimsley. *Acquisition, Retention, and Retraining: Effects of High and Low Fidelity in Training Devices*, HumRRO Technical Report 69-1, Human Resources Research Organization, Alexandria, Virginia, February 1969.

[3] R. Isley. *Inflight Performance After Zero, Ten, or Twenty Hours of Synthetic Instrument Flight Training*, HumRRO Professional Paper 23-68, Human Resources Research Organization, Alexandria, Virginia, June 1968.

[4] F. Muckler, J. Nygaard, L. O'Kelly, and A. Williams. *Psychological Variables in the Design of Flight Simulators for Training*, WADC Technical Report 56-369, Aeromedical Laboratory, Air Research and Development Command, Wright-Patterson AFB, Ohio, January 1959.

[5] W. Prophet and H. Boyd. *Device-Task Fidelity and Transfer of Training: Aircraft Cockpit Procedures Training*, HumRRO Technical Report 70-10, Human Resources Research Organization, Alexandria, Virginia, July 1970.

much physical similarity can lead to decreased transfer.[6] It is, however, possible to have fidelity in the simulation of psychological factors with limited simulation of physical factors. If successful, such a simulation would be very cost effective and it would allow close focus on the behavior under study while effectively excluding competing tasks. The actual tradeoff between cost and physical fidelity is affected by too many factors to allow the formulation of simple decision rules. The decision must be made on the basis of a systematic consideration of the behavior involved in the task at hand, and a careful appraisal of the resources required for a realistic level of physical fidelity.

A further aspect of simulation is that of abstraction. Harman[7] suggested that the varieties of simulation -- replication simulation, miniaturization, laboratory simulation, etc., could be ordered along a dimension of physical abstraction from the real world. One end of this continuum would be represented by a high-fidelity replication of the system and the other by a mathematical model. A good simulation would be designed at a level of abstraction which best represents the appropriate aspects of a system for cost-effective transfer of training.

The primary concern in the design of a target handoff simulator/trainer will be the determination of the dimensions of the tasks to be trained. The literature review contained in Chapter 2 of this report was

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[6] R. Ammons, C. Ammons, and R. Morgan. *Transfer of Training in a Simple Motor Skill Along the Speed Dimension*, WADC Technical Report 53-498, Wright Air Development Command, Wright-Patterson AFB, Ohio, 1954.

[7] H. Harman. *Simulation: A Survey*, System Development Corporation, Santa Monica, California, July 1961.

specifically aimed at identifying the psychological aspects of target handoff. From this review, it is apparent that the task primarily consists of one individual verbalizing visual imagery to another. The purpose of the exchange is to solve a problem (locate a target) in the minimum amount of time. Each individual has only partial information to reach a solution. The solution in the case of target handoff is the location and successful engagement of the target by an AH.

Initially, only the observer will know the target location and he must, by conveying a certain quantity of information, direct the AH pilot to it.

Therefore, the simulation must present visual stimuli to a pair of players, one of whom will act as the observer and the other as an AH pilot. The imagery presented to each player must duplicate as much as possible the view as it would be in real life. Differences in attitude, range, and angle must be incorporated into the images as appropriate. Whether or not the imagery presented to the individual playing the role of AH pilot should reflect the motion of the aircraft cannot be answered at this point. A study which would compare both still and motion picture imagery of comparable target areas would be necessary. It is clear, though, that motion picture imagery would be more expensive to produce as well as more expensive to project. An intermediate solution would be to use a series of still photographs taken from an aircraft as it moved toward the target location. Thus, the player in the pilot position would receive "updates" of the scene which might realistically relate to glimpses of the terrain seen by an AH "popping up" for orientation as it approaches a target area.

However, it seems that all of the basic aspects of the target handoff task can be contained in a minimum set of static imagery. As an example, two photographs of the same area with a target which differ only in camera position should provide the basic stimuli for a simulation of target handoff. Neither individual would be allowed to see the other's imagery, and some means of voice communication should be provided. Given a few rules and instructions, the players would then begin, one helping the other find the target. Intuitively, it appears that this simple-minded situation contains the essential elements of target handoff. A similar conclusion was reached by Simons and Valverde[8] in the USAF FAC/TAC target handoff research discussed earlier.

Initial research was aimed at devising a simple static simulation and evaluating its general suitability as a vehicle with which to further study target handoff. The equipment used for this pilot work is minimal -- a pair of 15x20" 3M "polacoat" back-projection screens, a pair of 35mm slide projectors, a set of Army field telephones to tie the players together, and a tape recorder to acquire and store the players' interchanges. This equipment is adequate for initial small pilot investigations. More sophisticated gear will be required for full scale investigation. The equipment furnishes each player with bright, sharp imagery and a means with which to conveniently communicate. In addition, the experimenter has the capability of monitoring their progress.

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[8] J. Simons and H. Valverde. *Voice Communications Training for Forward Air Controller/Strike Target Locators*, AFHRL(TR)-TRM-2, Advanced Systems Division, Wright-Patterson AFB, Ohio, January 1971.

The imagery required for the simulation should present a view to the observer player which would realistically simulate a target as seen from a ground position. The pilot player should view an image of the same area as it would appear from a longer range, a slightly higher altitude (30-100 feet) and possibly from a differing angle of regard. The ideal method to obtain this imagery would be to take pictures from an aircraft of an area containing a target, then photograph the same area from a ground position. This method would require detailed study of maps to select an area of terrain, followed by a fly-over to verify the nature of the terrain. Then a target(s) would be emplaced and photographs of the target area taken at several points along several preplanned flight paths. Ground photographs could be taken at the same time. It is estimated that a minimum useful set of imagery would consist of three different terrains, three different targets, three differing angles of view and two altitudes. This would yield 54 images usable for the pilot player. Additionally, if range to target were introduced as a factor, the number of useful images could be increased accordingly without much increase in time or cost. Each combination of terrain and target would be photographed from ground elevation to yield nine images for the observer player.

Unfortunately, it proved impossible within the time-frame of the contract to secure the required logistical support to acquire even this minimum set of imagery. Therefore, a substitute had to be found. A search revealed the existence of a possibly usable set of 35mm Ektachrome transparencies at the HumRRO Central Division in Pensacola, Florida. These transparencies were the basis of a set of training materials developed for low-altitude aerial observation and consist of view of terrain and

target objects taken from a variety of altitudes and angles of view. The set at Pensacola was composed of approximately 5000 slides. Accordingly, a staff member sorted through the set and selected those deemed most useful for a study of target handoff. The slides selected (107) can be separated into 12 categories. Six categories feature military targets, a 105mm howitzer, low clutter; a 105mm howitzer, high clutter; a caliber .50 machinegun, high clutter; a 106mm recoilless rifle, high clutter; and an M45 tank, high clutter. Determination of the degree of clutter was by the subjective judgment of the researchers who originally compiled the entire set of transparencies.

Additionally, six sets of transparencies of differing terrain were also acquired at Pensacola. Each set contains the same terrain photographed from different angles and elevations. No military targets are present in these transparencies, but each shows a number of features, i.e., vehicles, buildings, etc., that could be arbitrarily designated as targets. The terrain in these photographs is rolling, moderately hilly, with deciduous forest. Streams are present as well as numerous cultural features, e.g., roads, bridges, train tracks, buildings, etc. None of the transparencies feature a ground view. However, some of them were taken from a low elevation and can be employed to simulate the view an observer would see from a moderately high vantage point.

Unfortunately, on closer inspection, the transparencies were seen to vary greatly in density and color fidelity. In addition, since the transparencies are some 16-18 years old, time, in the form of scratches and smudges, has taken its toll. Thus, while these transparencies were determined to be useful for pilot studies, it is important to obtain new stimulus materials for further work.

The object of the initial study is to compare the performance of the experienced and inexperienced groups as they perform simulated target handoffs. Subjects are drawn from three populations and assigned to one of two groups. One sample is composed of individuals who have combat experience as AH pilots. These individuals serve as the pilot players in one group. The second sample is composed of individuals who have had combat experience handing off targets to air. These individuals are paired with the pilots and together they form the "experienced" group. The third sample consists of individuals drawn from the general population without any target handoff experience. These are randomly assigned player roles and constitute the "inexperienced" group. Due to time limitations and the small number of pilots available locally, it is unlikely that each group will contain more than eight pairs of subjects.

Four sets of transparencies were selected on the basis of pilot work for this first study. The criterion of performance is time to detection for each set. Thus, four data points represent the performance of each pair of players. The transparencies are presented in an approximate order of increasing difficulty. If the training supplied by the simulator is effective, then the performance of the two groups should differ. The learning of the experienced group should show acquisition quickly and reach an early asymptote. The inexperienced group should show a slower acquisition of skill but should approach the performance of the experienced group with continued trials.

The design of the study will, therefore, take the form of:

$$\underline{R} \quad \underline{O_1} \times \underline{O_2}$$

$$\underline{R} \quad \underline{O_3} \times \underline{O_4}$$

Where $\underline{R}$ indicates the random assignment of individuals to the groups.

Unfortunately, true random assignment will not be possible, and the assumption that the local groups are representative of the population is open to doubt. O_1 and O_3 are pretests, while O_2 and O_4 are posttests and x indicates the application of the experimental treatment.

In the concept of the current study, the groups differ with respect to an intrinsic attribute of the individual (experience). However, there is no means of certifying that the subjects are alike in all ways, save the possession (or lack) of experience. Therefore, a study with this design is vulnerable to alternative explanations of the results, based on the likelihood of other important differences between the groups. A variety of more complex alternative designs which would guard more fully against alternative hypotheses could be proposed. These, unfortunately, would require a significant increase in subjects and time. The best way to achieve validity, using the proposed design, is to ensure that the subjects are as homogeneous as possible. From casual observation, reinforced by questionnaire data, it appears that the potential pool of subjects at MASSTER is fairly homogeneous with regard to age, rank, education, and years of service. Therefore, it is felt that the simple design proposed will serve for achieving the limited objective of this initial study.

Given the ideal situation, the pre- and posttests would occur in an operational environment with real equipment. This would allow the measurement of transfer of training to the operational situation. However, since resources are scarce, the pre- and posttests consist of trials on the simulator.

Additional data is being gathered from the subjects at the time of experimentation. A simple personal history questionnaire was developed

to gather information in (a) years of service, (b) age and rank, and (c) education. This questionnaire is included in this report as Appendix B. Following the experimentation, the opinions of the experienced individuals are solicited as to the validity of their experience. Emphasis of these questions is on the psychological fidelity of the simulation rather than its physical characteristics.

This initial study began on 26 April 1976 after having experienced several delays occasioned by difficulties in obtaining equipment, space, and subjects. At the time of this writing, the study is still in process; hence, it is not possible to include the results in this report.

CHAPTER 5

SUMMARY, CONCLUSIONS AND DIRECTION FOR FUTURE RESEARCH

Summary

The bulk of the work carried out in the target handoff area was concerned with problem definition. An extensive review of Army documentation was accomplished to determine the scope of current training, doctrine and tactics. Additionally, several hundred documents from the general technical literature were reviewed for possible relevance to handoff. Selected documents were analyzed extensively and incorporated as Chapter 2 of this document. While little was found that directly addressed target handoff, a sufficiently large body of literature was found that addressed similar problems, or dealt with psychological processes that were hypothesized to underlie handoff.

In an effort to shed additional light on current Army handoff procedures, a number of experienced officers were identified and extensively interviewed concerning their handoff experience. This information revealed that the handoff universally occurred in Southeast Asia; however, the conditions under which handoff was carried out and the actual procedures used, varied considerably. Therefore, it was decided to develop a questionnaire which would allow the economical gathering of data concerning handoff from a relatively large sample of potential respondents. The resulting questionnaire was distributed to a sample of officers who had been identified as having handoff experience at HQ MASSTER. Additional data were obtained from a sample of attack helicopter pilots with the cooperation of the ARI Field Unit at Fort Rucker. These data were extensively analyzed and the results appear as Chapter 3 of this document.

Finally, it was determined that complete understanding of target handoff would require observations of the task as it was being accomplished. It was quickly determined that resources were not available for staging mock engagements involving handoff. Additionally, instrumentation was not available which would be required for recording the behavior of the individuals participating in the handoff. Faced with these difficulties in observing actual task behavior, it was decided to design a simple simulation that would allow the controlled observation of individuals performing the essentials of target handoff. The design goals of this simulation were to establish an acceptable degree of psychological fidelity and minimum concern was placed on achieving physical fidelity. The resultant simulation used static imagery presented to two players, one with the role of pilot and one with the role of ground observer. The imagery presented to the "observer" showed a military target emplaced in rolling wooded terrain. The imagery presented to the "pilot" showed the same terrain with target but from a longer distance, a greater altitude, and a differing angle of regard. Equipment was provided which would allow voice communications between the players, with a recording device to store their verbal interchange. The simulation is described in detail in Chapter 4.

This simple simulation was also intended to serve as a test bed for the initial tryout of experimental handoff procedures. An initial study was designed that would compare the performance of experienced pilots and ground observers to the performance of inexperienced pilots.

This study was intended to serve as a first step in the determination of the adequacy of the simulation as a training device. Unfortunately,

lack of resources and difficulty in procuring experimental subjects delayed the study so that the results were not available for inclusion in this report.

Conclusions

The effort in studying target handoff has resulted in the following conclusions concerning existing procedures:

- No formal training in handoff procedures currently exists.
- The elements of the handoff message are specified, but the content of the elements is not.
- Local unit SOP is currently the basis for target handoff procedures.
- The individuals interacting in the handoff may differ widely in many characteristics.
- Almost anyone with access to voice communications channels can request Army air firepower.
- Realistically, most of the requests for Army air support will come from platoon leaders or company commanders.

Review of the relevant literature revealed two areas of research that served to focus future target handoff research. The first was an effort by the USAF to develop procedures for improved air-to-air handoff. This research was programmatic in nature and has great relevance to the research on air-to-ground or ground-to-air handoff.

This USAF research focused on the verbal exchange between an airborne FAC and the pilot of a high-performance aircraft. This interchange occurred as the FAC tried to describe the target and its location to the pilot. Considerable research was carried out to determine the characteristics of an effective handoff message, and also to develop a standard lexicon of terrain descriptors. Other investigators looked at

the usefulness of unconventional distance and heading units. Finally, several individuals looked at the possibilities of developing a simple trainer to provide experience in handoff without the need of involving actual aircraft. This trainer was constructed and a number of studies carried out assessing its effectiveness. This trainer provided the stimulus for the target handoff simulation described in Chapter 4.

The second influential area of research unearthed by the literature review is in the area of social psychology. Specifically, this research concerned problem-solving communication between members of a dyad. In this communication, which is referred to in the literature as *convergent communications,* one individual had knowledge of the solution of a problem and was tasked with communicating this information to another individual who would implement the solution. There is a striking similarity between the behaviors involved in convergent communications and those which accompany target handoff. As a result, a number of hypotheses which were posited to result in improved convergent communications, may be transferred directly to the target handoff research.

These hypotheses concern the nature of the message as well as characteristics of the individuals communicating. The nature of the referent of the communication is also important. However, since it is not appropriate to vary the referent, this research will focus on the message and the relevant characteristics of the communicator. Briefly, these hypotheses concern the question of optimal message rate, the optimal sequence of message events, the role of feedback and acknowledgement, and the effects of the communicator's mode of information processing. It is expected that the simulator will be used in experimentally determining answers to these research questions.

The data from the handoff questionnaire revealed that a wide variety of handoff procedures were used. These procedures would only be viable with absolute air superiority against an unsophisticated enemy. In addition, the circumstances surrounding the handoff (i.e., geography, vegetation) were probably unique to the Vietnam conflict. Data were also collected by the questionnaire which were intended to serve as the basis for a typical mission profile. Unfortunately, the variability of the responses tended to be so large as to render the assemblage of a "typical" mission unrealistic.

Direction for Future Research

The first step in continuing the target handoff research will be to acquire more suitable imagery for the simulation. With this in hand, steps should also be taken to improve the equipment being used. Specifically, better voice communications gear, and booths which will further isolate the experimental subjects, are definitely required.

Once the equipment is optimized, a series of studies should be carried out to determine:

- What is the advantage of convergent communication *versus* free unaided search in the acquisition of targets.
- What are the characteristics of a "good" (rapid) handoff message.
- What are the personal characteristics of the dyad who are successful (i.e., perform rapidly) in performing handoff.
- What are the effects of lexicon training on effective handoff.
- What are the effects of search strategy training.

- What are the effects of message information rate.

- What are the effects of a message format that emphasizes acknowledgement and feedback.

Finally, these and other hypotheses, even if confirmed in laboratory study, must be confirmed in the field with operational equipment. This experiment will require considerable resources in personnel and equipment, but without it, there will be no way of validating the improved procedures.

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APPENDIXES

APPENDIX A

TARGET HANDOFF QUESTIONNAIRE

TARGET HANDOFF QUESTIONNAIRE

NAME ____ RANK ________
(Last) (First) (Middle)

CURRENT DUTY ______________________________ PRIMARY MOS __________

Instructions

We are very interested in your experiences in target handoff, particularly any problems you may have experienced. Your responses will be valuable in increasing our understanding of the task and will be useful in the production of improved handoff procedures.

The questionnaire is divided into two parts. If you have handed off a target from ground-to-air, respond to Part I (ground). If your experience is as a pilot or observer, respond to Part II (air). If you have experience in both capacities, complete both parts of the questionnaire.

PART I - GROUND

1. Briefly describe your role in handing off a target to Army air. Include your unit and your function within the unit, and the geographical setting and time frame of your experience:

2. How many times did you attempt to handoff a target to air? (Please estimate) ________

3. What percentage of these handoffs resulted in a successful engagement? ________%

4. Please estimate the percentage of times that a mission was not completed due to unintelligible communication: ________%

5. Please estimate the percentage of communications you had to ask for clarification of: ________%

6. Please estimate the percentage of hand-offs that you designated the target using each of the following methods:

   ____ (a) Smoke and/or WP

   ____ (b) Verbally, with grid coordinates

   ____ (c) Verbally, by range and direction from a known point

   ____ (d) Verbally, by range and direction from smoke

   ____ (e) Used panels to mark target heading

   ____ (f) Other (Please specify) ________________________

7. If coordinates were used, how often were the coordinates accurate?

____ (a) Always

____ (b) Most of the time

____ (c) Some of the time

____ (d) Never

____ (e) Never used coordinates

8. Terrain features (i.e., trees, hills, cultural features, lakes, etc.) are often used as reference points in target designation. Please list below, in approximate order of usefulness, terrain features that you have used as reference points:

a. ______________________ d. ______________________

b. ______________________ e. ______________________

c. ______________________ f. ______________________

9. Please estimate the percentage of time you found each of the following tasks difficult to accomplish:

____ (a) Give the AH pilot a complete target briefing.

(b) Get the chopper to see the target by:

____ (1) referencing the target location to a known point,

____ (2) directing the AH's maneuvers.

10. Please estimate the percentage of missions on which you have personally encountered each of the following problems during target handoff: (Estimate % for each item and enter before each item - do not try to make the items sum to 100%)

____ (a) Inappropriate, unfamiliar, or confusing terminology used in reference to terrain, target, or ordnance.

____ (b) Confusion or error in ranging call signs.

____ (c) Unnecessary chatter.

____ (d) Poor enunciation over voice channels (not system-related).

____ (e) Lack of prominent landmark at CK point or rendezvous point.

____ (f) Misunderstood or miscopied coordinates.

____ (g) Pilot confused intended terrain feature with another.

____ (h) Strike AH at wrong location.

____ (i) Strike AH arrived too late.

____ (j) Target obscured by foliage.

____ (k) Wrong target marked.

____ (l) Smoke markers could not be distinguished from other smoke.

____ (m) Could see target but AH could not.

____ (n) Strike pilot could not understand your description of terrain features or your orientation.

____ (o) You could see prominent orienting features, but AH apparently could not.

____ (p) Ground judgment of distance to target was different from airborne judgment of distance.

____ (q) Pilot ignored orienting instructions.

____ (r) Strike came in on wrong azimuth.

____ (s) Corrections in fire were not understood by AH pilot.

11. There is great concern that current training may be inadequate for a future mid-intense conflict. In your opinion, how much emphasis should be placed on each of the following areas? (Rank the content areas below from 1 to 6, with 1 = greatest emphasis)

RANK

(a) Specific training in handoff procedures. ____

(b) Improved target marking procedures. ____

(c) Improved pre-strike briefing. ____

(d) Compass use. ____

(e) Map reading. ____

(f) Contour interpretation. ____

12. What was the range of distances from you to the target? ________

13. How far were you usually from the target? ________

14. What was the range of distances from your position to the helicopter position when contact was first established? ____________

15. What was the typical distance from your position to initial helicopter position? ________

16. On what percentage of your missions did the AH arrive directly over your position at the target area? ______%

17. What was the range of distances between you and the AH when the AH arrived in the target area? ________

18. What was the typical distance between you and the AH when the AH arrived in the target area? ________

19. We also need information regarding the type of target that was subjected to air attack. Please list below, in order of decreasing frequency, targets that resulted in a request for Army close-air support:

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

PART II - AIR

1. Have you had experience as an AH pilot? YES ___ NO ___

2. If you answered "YES" above, how many combat missions have you flown? ___________

3. Have you had experience as an observer in an attack helicopter?
YES ___ NO ___

4. If you answered "YES" above, how many combat missions have you flown?
____

5. Please estimate the number of handoffs you have received. ___________

6. What percentage of these handoffs resulted in a successful engagement?
___________ %

7. How many times did you attempt to handoff a target to ground?
(Please estimate). ___________

8. Please estimate the percentage of times that a mission was not completed due to unintelligible communication: ___________ %

9. Please estimate the percentage of communications you had to ask for clarification of: ___________ %

10. Please estimate the percentage of times that ground designated the target location using each of the following methods:

____ (a) Smoke and/or WP

____ (b) Verbally, with grid coordinates

____ (c) Verbally, by range and direction from a known point

____ (d) Verbally, by range and direction from smoke

____ (e) Used panels to mark target heading

____ (f) Other (Please specify) ________________________

11. If coordinates were used, how often were the coordinates accurate?

____ (a) Always

____ (b) Most of the time

____ (c) Some of the time

____ (d) Never

____ (e) Never used coordinates

12. Terrain features (i.e., trees, hills, cultural features, lakes, etc.) are often used as reference points in target designation. Please list below, in approximate order of usefulness, terrain features that were used as reference points:

a. ____________________ d. ____________________

b. ____________________ e. ____________________

c. ____________________ f. ____________________

13. Please estimate the percentage of missions on which you found each of the following tasks difficult to accomplish:

____ (a) Navigate to target area.

____ (b) Locate target when at target area.

14. **Please estimate the percentage of missions on which you have personally encountered each of the following problems during target handoff: (Estimate % for each item and enter before each item - do not try to make the items sum to 100%)**

____ **(a) Inappropriate, unfamiliar, or confusing terminology used in reference to terrain, target, or ordnance.**

____ **(b) Confusion or error in ranging call signs.**

____ **(c) Unnecessary chatter.**

____ **(d) Poor enunciation over voice channels (not system-related).**

____ **(e) Lack of prominent landmark at CK point or rendezvous point.**

____ **(f) Misunderstood or miscopied coordinates.**

____ **(g) Given an incorrect heading.**

____ **(h) Confused intended terrain feature with another.**

____ **(i) Target obscured by foliage.**

____ **(j) Wrong target marked.**

____ **(k) Smoke markers could not be distinguished from other smoke.**

____ **(l) Ground judgment of distance to target was different from airborne judgment of distance.**

____ **(m) Heading was not accurate.**

____ **(n) Description of terrain was not familiar.**

____ **(o) Pilot ignored orienting instructions.**

15. There is great concern that current training may be inadequate for a future mid-intense conflict. In your opinion, how much training emphasis should be placed on each of the following areas? (Rank the content areas below from 1 to 6, with 1 = greatest emphasis)

	RANK
(a) Specific training in handoff procedures.	____
(b) Improved target marking procedures.	____
(c) Improved pre-strike briefing.	____
(d) Compass use.	____
(e) Map reading.	____
(f) Contour interpretation.	____

16. What was the range of distances from the ground position to the target? ________

17. What was the typical distance from the ground position to the target?

____

18. What was the range of distances from the point of initial contact with ground to the target location? ________

19. What was the typical distance from the point of initial contact with ground to the target location? ________

20. What range of altitudes did you maintain from initial contact to the target area? ________

21. What was the typical altitude maintained from initial contact to the target area? ______________

22. What range of speeds did you maintain during approach? ______________

23. What typical speed did you maintain during approach? ______________

24. On what percentage of your missions did you arrive directly over the ground position at the target area? ____________%

25. What was the range of distances between you and the ground observer when you arrived in the target area? ______________

26. What was the typical distance between you and the ground observer when you arrived in the target area? ______________

APPENDIX B

PERSONAL HISTORY QUESTIONNAIRE

Position P ___ O ___ Group E ___ O ___

Paired With ______________

Time 1 ______________ Time 4 ______________

Time 2 ______________ Time 5 ______________

Time 3 ______________

DO NOT MARK ABOVE THIS LINE

PERSONAL HISTORY

Name: ______________________________ Rank: __________
(Last) (First) (Initial)

Primary MOS: ______________________ Years Service ______

Age: ________

1. How far did you go in school?

___ a. High School or GED

___ b. Had some college work

___ c. Graduated from college

___ d. Completed some graduate training

___ e. Completed Masters

___ f. Completed Ph.D.

___ g. Post Doctoral

2. What was your undergraduate academic major?

___ a. Physical sciences (physics, chemistry, etc.)

___ b. Humanities (art, music, etc.)

___ c. Social sciences (sociology, history, political science psychology, etc.)

___ d. Engineering

(continued)

___ e. Business, accounting

___ f. Other (Specify) ______________________

3. What was your graduate major (if applicable)?

___ a. Physical sciences (physics, chemistry, etc.)

___ b. Humanities (art, music, etc.)

___ c. Social sciences (sociology, history, political science, psychology, etc.)

___ d. Engineering

___ e. Business, accounting

___ f. Other (Specify) ______________________

4. In college, which type of course did you enjoy most?

___ a. Lecture

___ b. Lab

___ c. Discussions

___ d. No preference

5. What was your scholastic standing as an undergraduate?

___ a. Upper 25% of class

___ b. Middle 50% of class

___ c. Lower 25% of class

The simulated handoffs you have participated in are a part of a first effort in an attempt to get a better look at the task of target handoff. No effort was made to achieve physical similarity between the equipment used and operational equipment. Disregarding the physical aspects of the simulation, how would you rate your experience?

___ 1. Having all of the essential characteristics of the "real" handoff.

___ 2. Having most of the essential characteristics of the "real" handoff.

(continued)

___ 3. Having some of the essential characteristics of the "real" handoff.

___ 4. Having few of the essential characteristics of the "real" handoff.

___ 5. Having none of the essential characteristics of the "real" handoff.

Please comment, or amplify your response below: